AD-A129 679 PROGRAM MANAGER: THE JOURNAL OF THE DEFENSE SYSTEMS MANAGEMENT COLLEGE VOLUME XII NUMBER 3 MAY-JUNE 1983 (U) DEFENSE SYSTEMS MANAGEMENT SCHOOL FORT BELVOIR VA 1983

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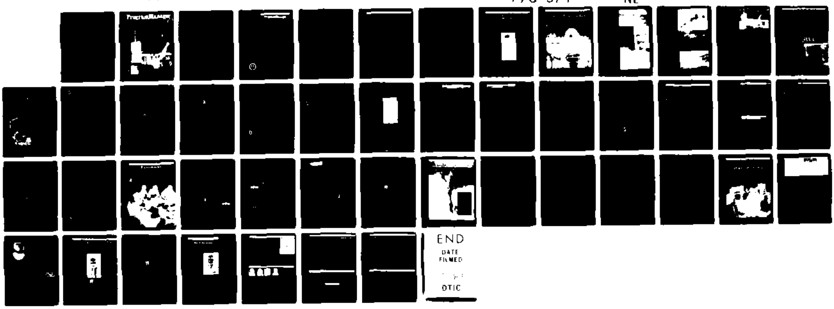

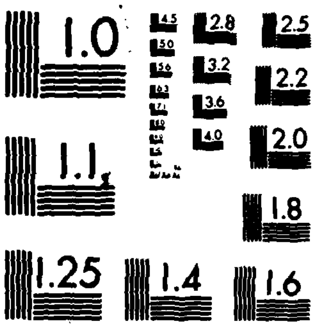

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May-June 1983

ProgramManager

The Journal of the Defense Systems Management College

11

Second Sourcing to Enhance Competition

Brainsidedness: What We Do Know Can Help Us

Profit and Profitability: What Price Defense?

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Program Manager (ISSN 0199-7114) is published bimonthly by the Defense Systems Management College, Fort Belvoir, Va. 22060, and is intended to be a vehicle for the transmission of information on policies, trends, events, and current thinking affecting program management and defense systems acquisition.

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POSTMASTER: Send address changes to Editor-in-Chief, *Program Manager*, Defense Systems Management College, Fort Belvoir, Va. 22060.

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ProgramManager

Vol. XII, No. 3
DSMC 54

Productivity Defined; More Efforts Recognized

Dear Sir:

In Professor David D. Acker's recent article in *Program Manager* on the subject of productivity enhancement ["Productivity Enhancement: A Clear and Present Challenge," March-April 1983], he used two equations to define productivity. The second equation, credited to George Kuper, does not appear to be correct. The equation states:

$$\text{Productivity} = \frac{\text{Effectiveness}}{\text{Efficiency}}$$

Can you provide a more complete explanation of this ratio?

Ibrahim A. Ashie
Strategic Systems Project Office
Training Systems Branch
HQ Naval Material Command

The author replies:

To begin, productivity can be viewed as reaching the highest level of performance with the least expenditure of resources. All that follows is based on that premise.

Simply stated, productivity is the ratio of output to input, both measures being expressed in the same units. This productivity ratio can be applied to almost any kind of human endeavor—to all segments of work in industry, government, service groups, education, and professional organizations. When we apply the ratio, we usually express it as an index in which the current position is compared with the position during the next period. If the ratio increases, we are doing whatever we have been doing more efficiently.

At the national level, productivity can be expressed as:

$$\frac{\text{Gross National Product}}{\text{labor} + \text{capital}}$$

A partial productivity ratio could be expressed in terms of labor or capital, i.e.,

$$\text{labor productivity} = \frac{\text{GNP}}{\text{labor}}$$

$$\text{capital productivity} = \frac{\text{GNP}}{\text{capital}}$$

Most of us associate the concept of productivity with industrial firms rather than with the country as a whole. At the industrial level productivity is visible, tangible, and more easily measured. Focusing on the industrial firm, there are several ratios that one can use to express productivity in definitive terms. For example, one ratio that might be used to express the efficiency of the entire firm is as follows:

$$\text{Productivity} = \frac{\text{product} + \text{service}}{\text{labor} + \text{materials} + \text{overhead} + \text{capital}}$$

This productivity ratio is an all-inclusive statement of the value of the product and service produced based upon a summary of the value of all the inputs used. In this example, money (dollars) is used in both the numerator and denominator to allow the diverse products and resources to be expressed in equivalent terms. Special adaptations of the basic productivity ratio could be made to represent the functions in any manufacturing organization. For example, a firm-wide productivity ratio could be expressed in any one of the following ways:

$$\frac{\text{sales} + \text{inventory change} + \text{plant}}{\text{labor} + \text{material} + \text{services} + \text{depreciation} + \text{investment}}$$

$$\frac{\text{shipments}}{(\text{direct labor}) + (\text{indirect labor}) + (\text{materials})}$$

$$\frac{\text{revenue}}{\left(\substack{\text{direct}\\\text{labor}}\right)+\left(\substack{\text{indirect}\\\text{labor}}\right)+\left(\substack{\text{total direct}\\\text{procurement}}\right)+\left(\substack{\text{other}\\\text{expenses}}\right)+\left(\substack{\text{capital}\\\text{cost}}\right)-\left(\substack{\text{inventory}\\\text{change}}\right)}$$

$$\frac{\text{total goods and services billed}}{\left(\substack{\text{employee}\\\text{compensation}}\right)+\left(\substack{\text{direct}\\\text{material cost}}\right)+\left(\substack{\text{facilities}\\\text{change}}\right)+\left(\substack{\text{business}\\\text{service cost}}\right)}$$

$$\frac{\left(\substack{\text{production}\\\text{cost}}\right)-\left(\substack{\text{purchased}\\\text{material cost}}\right)-(\text{depreciation})-(\text{taxes})}{\left(\substack{\text{labor}\\\text{input cost}}\right)-\left(\substack{\text{net}\\\text{investment}}\times\substack{\text{rate of}\\\text{return}}\right)}$$

The preferred productivity ratio for any endeavor is the one that best fits the purpose and resources of the organization involved. Practice, comparative use, and historic validation are some of the methods for giving productivity ratios meaning and/or validity. Shown below are several examples of productivity measures for individuals or units that have been used:

$$\frac{\text{problems solved}}{\text{worker hour}} \qquad \frac{\text{projects completed}}{\text{projects planned}}$$

$$\frac{\text{engineering drawings}}{\text{design engineer}} \qquad \frac{\text{budget performance}}{\text{budget authorized}}$$

$$\frac{\text{output obtained}}{\text{input expended}} \qquad \frac{\text{benefits}}{\text{costs}}$$

$$\frac{\text{results achieved}}{\text{resources consumed}}$$

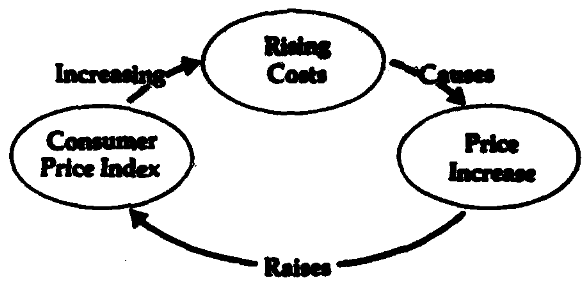
In measuring the productivity of a service organization, such as a data processing organization, measures of effectiveness are sometimes combined with measures of efficiency. The effectiveness of data processing operations can be defined by the timeliness of the organization in meeting the output schedule. The efficiency can be defined by the extent of the utilization of the computer and the peripheral support devices. Let's assume that efficiency will be measured by traditional output-input ratios and effectiveness is related to the quality of the output. If a number of points are allocated for each measure, and the total score is computed for each time period being measured, the results will represent the total effectiveness score and the total efficiency score for each time period. In this example, the productivity of the data processing operation can be defined as the product of effectiveness multiplied by efficiency. Because there isn't a constant measure of output in this example, the effectiveness score should be multiplied by the familiar efficiency (output-input) ratio as shown below:

$$\text{Productivity} = \text{effectiveness} \times \frac{\text{output}}{\text{input}}$$

This example illustrates an important assumption regarding simple productivity ratios: The quality or effectiveness of the output has to be held constant. In an era of rapidly changing technology, comparisons of output become almost meaningless. In the service area, such as the one described above, the definitions are very difficult to formulate. Whether one is concerned with a product or a service area, there are three primary methods for increasing productivity—through the work force, the work methods, and the equipment.

In my article I indicated that George Kuper, former acting director of the National Commission on Productivity and Work Quality, thinks of productivity as a combination of effectiveness and efficiency. To determine productivity one must ask: First, was the desired result achieved? (the effectiveness question) and, second, what was the quantity of resources consumed to achieve it? (the efficiency question). Effectiveness relates to performance; efficiency, to resource utilization. How well resources are brought together and utilized is indicated by comparing the magnitude/volume of results, usually called the output (effectiveness), with the magnitude/volume of the resources consumed, usually called the input (efficiency). This ratio becomes an index of the definition and a measurement of productivity.

Reviewing what I have said in this discussion of productivity, the simplest type of productivity is labor productivity, i.e., output per unit of worker input. Because it is possible to increase workers' productivity by wasting more material or using more energy, it is usually wise to consider a wider index—one that includes materials and the consumption of resources, such as electricity. One can also increase productivity by making a capital investment in more efficient facilities and equipment. It follows that, with a wide range of factors to be considered, there is a need for a common unit of measurement. Money (dollars) is probably the most used unit of measurement. Of course, the use of a money scale raises additional problems, mainly when inflation has to be considered. In determining productivity, one has to divorce price changes from usage changes. The total productivity of an industrial firm has to take into consideration the changes in outputs and usages at base year prices.



The Inflationary Cycle

If we recognize that productivity is the capacity to utilize our existing resources to meet the expanding needs of each of us, then the case for managing and enhancing productivity is stronger and more urgent today than it ever was in the past. The growing pressures from many segments of our society make it imperative that breakthroughs take place in productivity. When these breakthroughs take place, our standard of living and the quality of our work life will improve. On a national level, productivity enhancement is the only source of increased real national wealth. Fortunately, although the United States has fallen behind the productivity growth rate of most industrialized nations, this country still has the most productive work force in the world.

Dear Sir:

We enjoyed the article on productivity enhancement by Mr. David D. Acker. It was well documented and very informative.

However, in the paragraph on service technology programs, the Army's first Industrial Productivity Improvement (IPI) Program at Avco Lycoming was not mentioned.

We at Avco Lycoming feel it is only appropriate that our program receive recognition. Those involved in the IPI Program at Avco Lycoming have endeavored diligently to create a truly successful program.

It is my contention that the IPI/Tech Mod programs offer the methodology to rebuild the declining industrial base. The IPI Program is the mechanism that will make partners out of the defense contractor and the government, making it a true win-win situation.

David A. Keith
Major TC
Training With Industry
Avco Lycoming

In an earlier draft of Mr. Acker's article, he included a section that addressed, in general terms, the various IPI/Tech Mod programs of the services. That section was eliminated from the final version of the paper, but we are happy to recognize the Army's efforts at Avco Lycoming. Ed.

VIEWPOINTS

Independent Research and Development

Gateway to Supportability

General James P. Mullins, USAF
Commander, U.S. Air Force Logistics Command

Recently, more and more discussion has been taking place within the defense community regarding weapon system design and acquisition. And that's good, because there are many vital issues here which substantially affect this nation's defense posture, and which need honest and comprehensive evaluations.

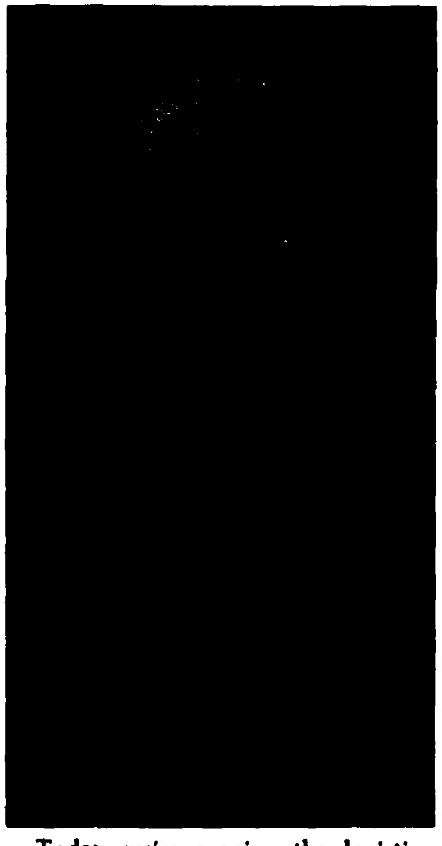
In making such evaluations, however, we should remember that our military establishment exists for only one purpose—to be able to fight in combat and win, thereby deterring any potential aggression. More Americans should remember that this is our only purpose—that it is, in fact, the military's only *real* function.

For this reason, I believe our ability to fight in combat, and win, must be the only measure of merit by which we judge ourselves and what we do. The weapon systems we buy must be designed and built with only that purpose in mind. For, given the nature of modern warfare—how fast it can occur and how vulnerable we are to it—our weapons must be ready to do the job whenever and wherever they're needed.

The Readiness Issue

But frankly, we have problems in this area. We have many systems today that are overly dependent on antiquated or immature technologies, complex maintenance, and long lead times for the procurement of spare engines and parts. This forces us to rely on weapon systems that would be difficult, if not impossible, to support logistically in a protracted war.

The question is, why have we done this to ourselves? What has caused us to design, build, and field systems that lack the necessary durability and reliability? I believe a major part of the problem has been our traditional approach to research and development. In fact, I'm convinced that, over the years, we've gotten exactly the type of weapon systems we've asked for. In other words, what we tolerated is what we got.



Today we're reaping the logistics problems that were sown through years of infatuation with operational parameters; that is, with how fast our systems would go, how high they would fly, or how powerful they would be. These are important considerations, to be sure; but the fourth operational parameter—supportability—has been largely ignored in the development process.

We're paying the logistics price for training scientists and engineers to think primarily in terms of how fast, how high, and how powerful. We're paying the price in terms of logistics problems resulting from R&D activities too heavily biased against up-front logistics considerations.

Many of the difficulties we face today can be traced, I believe, to our lack of emphasis on reliability and supportability in the independent research and development (IR&D) effort that precedes the formal development process. We need to look more closely at IR&D, because that's where ideas are conceived that are later turned into reality. Unfortunately, all too much of the IR&D that industry invests for the military market is directed toward performance rather than support. Why can't some of the technical innovation that characterizes IR&D be applied toward reducing logistic and manpower burdens? Why can't the same emphasis be given to mission reliability as to mission capability? Why is such a small percentage of industry's IR&D activities directly related to logistics?

Since IR&D is neither government funded nor directed, defense contractors are free to focus their attention wherever they choose. If, however, they expect to be reimbursed for at least a portion of their IR&D expenditure, they must develop a technological concept the government will turn into a formal requirement (and a formal contract with the company). Obviously, then, the contractor's IR&D decision must be based on what he believes the Defense Department will ultimately buy. His corporate strategy is based on the priorities we in the military have set; and he will direct his IR&D activities precisely where he should, given

(continued on page 42)

Acquiring Systems at Economic Production Rates

A recently completed study shows program managers how to determine the best production rates for their systems—and the problems they may face in achieving those rates.

David D. Acker

To help ensure implementation of Department of Defense Acquisition Improvement Program Action 7, Economic Production Rates, the Defense Systems Management College (DSMC) sponsored a special study of this subject in support of the Office of the Secretary of Defense (OSD). The 7-month study was conducted by Advanced Technology, Inc.—as the result of a competitive award—under the leadership of Edward J. Downing. I served as the DSMC Project Officer. The final report, titled "Economic Production Rate Study," was issued in March 1983.

Background

The DOD Acquisition Improvement Program mandates that the services use economic production rates in their program and budget requests; if not, they

Producing defense systems at economical production rates decreases the time it takes to get those systems into the hands of the troops.

must present rationale for using a different rate. Producing a defense system at an economic production rate can provide a financial savings, decrease the production time for the system, and decrease the time to complete deployment of the system. Conversely, operating at a high rate of production can result in early completion of the total defense system production requirements. At the same time, a high production rate can place excessive workload demands on the contractors(s) and subcontractor(s) involved.

The spirit of Action 7 carried through the FY 81 supplemental and FY 82 amended budgets. The production rates for several programs that were being funded at inefficient rates were increased or restored to more economic levels. This momentum toward high-rate, efficient production continued when the services submitted their FY 83 Program Objectives Memorandum (POM) requests. The services were directed by the Defense Resources Board (DRB) to establish offsets in the FY 83 budget to allow production at more economical rates for certain systems, such as the Mark-48 torpedo, the TOW anti-tank missile, the F-18 fighter, and the re-engining of the KC-135 tanker. Unfortunately, during 1981 the target figures for the top line fluctuated and the defense systems acquisition process showed little versatility to adapt to budget uncertainty.

There were several barriers to implementation of Action 7 at the outset. The principal barriers were:

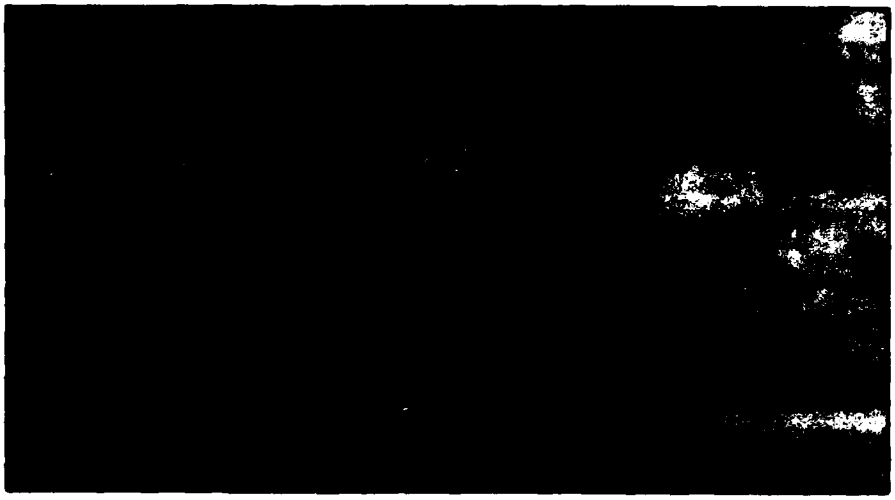
—The uncertainty of the defense program budget level.

—Little commitment by OSD or the services to establish priorities and cancel marginal programs in response to reductions in the budget.

—Legitimate reasons for producing at rates that were not economical. These reasons included production problems, technical problems, and program instability.

—Maintaining a "warm" production line may be more important to our defense industrial base than producing a defense system at the economic production rate.

■ *Mr. Acker is a Professor of Engineering Management in the Research Directorate at DSMC.* ■



The services were directed to establish offsets in the FY 83 budget to allow production at more economical rates for certain systems, including those pictured here.

CFM International

(Top) Navy F/A-18 Hornet.

(Right) Improved efficiency CFM56 engine for the Air Force KC-135R re-engining program.

(Bottom) The Army's TOW wire-guided anti-tank missile.

—The production rate may be set at the level that meets the threat to our national security. This is not always the most economic rate.

Objectives of Study

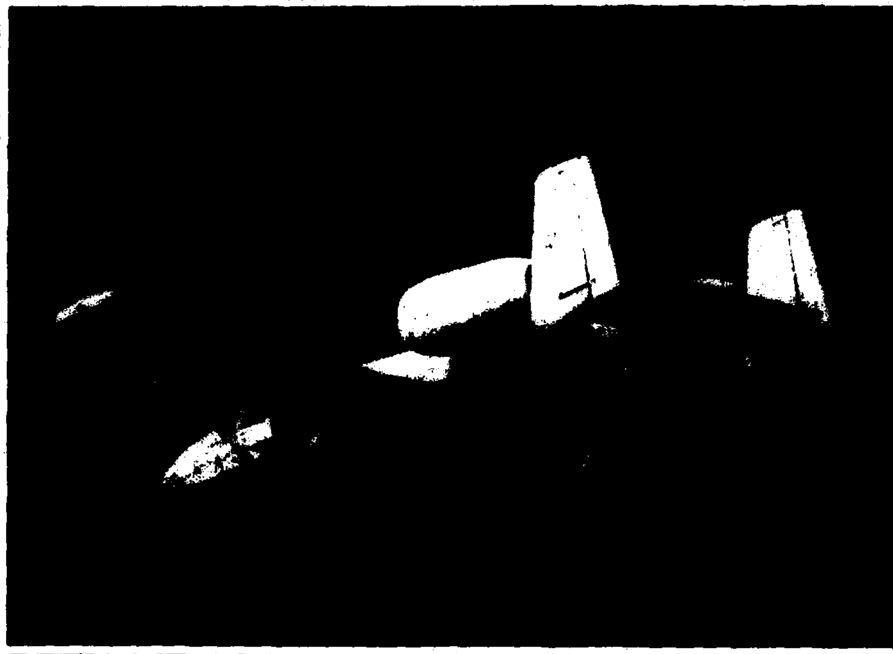
The basic objective of the study sponsored by DSMC was to determine, using sound microeconomic theory, how an economic production rate should be determined. To do so, a definition was needed; therefore, the development of a suitable definition became one of the study objectives. Another objective of the study was to determine the underlying reasons why some defense systems were not produced at economic production rates.

Summary of Study Results

No simple analytical model was found to define "economic production rate" (EPR); therefore, a definition was developed by Advanced Technology based upon the results of discussions with members of the defense systems acquisition community. To describe this rate it was necessary to define "economic *procurement* rate" as well as "economic *production* rate."

The economic procurement rate is the rate of acquisition of a complete system. It can be defined as the rate of procurement that permits efficient use of available industrial resources to achieve the lowest unit cost. The word "procurement" is used here to distinguish between the acquisition rate of the complete system and the rate at which the components of the system are produced.

In practice, each contractor has its own economic production rate. These rates must be taken into account when evaluating the procurement rate of the system. The contractor with the lowest economic production rate will act to limit the overall procurement of the system. The economic procurement rate, by definition, is the same as the prime's or subcontractor's lowest economic production rate, depending on whose rate is the limiting rate (i.e., sometimes it is the same as the contractor's lowest EPR; sometimes it is the same as the subcontractor's lowest EPR). This definition of EPR should not be associated with the models which measure the cost effect of rate changes. The EPR is determined by the government program management office through discussion with the contractor(s). In this way, the E...



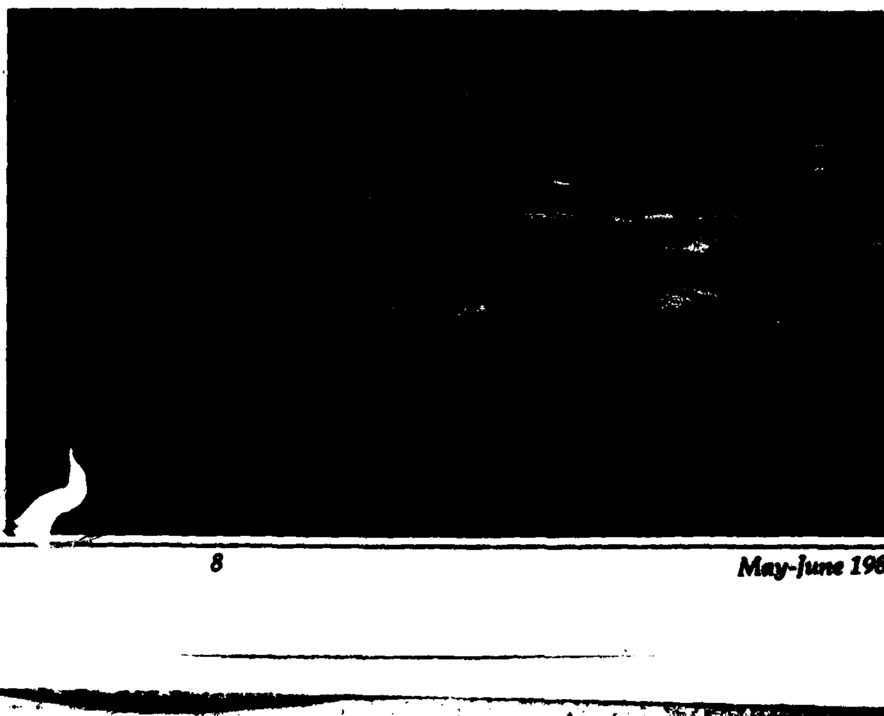
In practice, contractors usually produce, and program offices usually procure, below the optimum rates.

These systems were examined as part of the study of economic prodution rates.

(Top) Air Force A-10 Thunderbolt.

(Middle) Navy A-6E Intruder.

(Bottom) Army Abrams M-1 tank.



each contractor can be found by deciding the rate at which the industrial resources available will be used efficiently.

Planning for economic production rates must begin early enough in a program to influence the many contractor decisions that will determine the EPR. As early as the demonstration and validation phase, decisions on production quantities and production funds will greatly influence the EPR. During the production and deployment phase, the production rate should be maintained at the predetermined EPR in order to make the most efficient use of available industrial resources. If a change in production rate is required, it should be changed to some predetermined production-rate level.

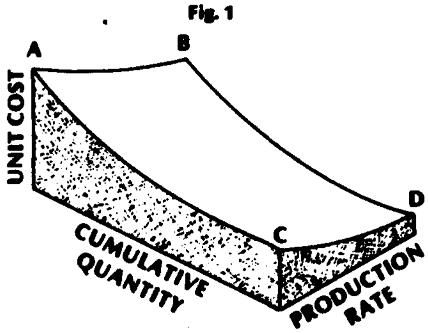
The production-cost changes resulting from a change in production rate may be estimated either through direct discussion with the manufacturer, or through a modeling technique, or both. There are several models that can be used to predict the effect of a production-rate change on unit cost. Unfortunately, many models require data that are very difficult to obtain, such as contractor variable and fixed costs.

The model used in support of the study is one that has also been used by John C. Bemis, formerly of the DOD Product Engineering Services Office (PESO). Through a multiple regression analysis of cost and schedule data, an equation was derived for each program studied. This equation shown below associates the manufacturer's unit "flyaway" cost (UC) with the cumulative number of units produced (Q) and the rate of production of the item (R).

$$UC = (k)\, Q^{-.xxx} R^{-.yyy}$$

where: constants k, .xxx, and .yyy are determined by regression analysis using a least-squares fit through the data points. A physical model would appear as shown in Figure 1.

Fig. 1

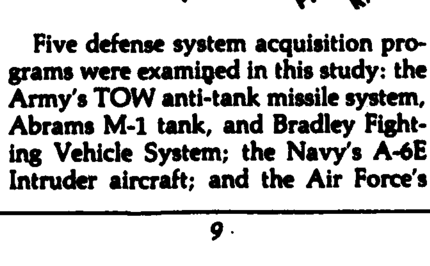


Torpedo MK-48 being loaded aboard the USS Queenfish (SSN-651)

The scalloped surface ABD represents the solution to the equation. Point A is the highest point on the surface and corresponds to cost of the first unit produced at the lowest production rate. It also represents the "prime unit cost." Note that curve AC is a cost-improvement curve at the lowest production rate. Point A corresponds to the first unit cost of that curve. The surface is concave with point D being the lowest unit cost.

One of the features of this model is that unit cost can be lowered by increasing either cumulative quantity, or production rate, or both. Plotting combinations of cumulative quantity and production rate which yield the same unit cost will describe an isocost line. A family of isocost lines is shown in Figure 2.

Fig. 2



Five defense system acquisition programs were examined in this study: the Army's TOW anti-tank missile system, Abrams M-1 tank, and Bradley Fighting Vehicle System; the Navy's A-6E Intruder aircraft; and the Air Force's A-10 Thunderbolt attack aircraft. For each program, a regression analysis was performed based on the equation previously described. For the A-10 aircraft, fixed overhead data was available. In that case, the model suggested by Dr. Charles H. Smith, while serving at the Army Procurement Research Office at Ft. Lee, Va., could be used. The economic procurement rates for the five systems studied were determined and the results are presented in the report.

The economic production and procurement rates represent goals. In practice, contractors usually produce, and program management offices usually procure, below the optimum rates. The prevalent reason for procuring (producing) a defense system below the EPR is affordability. Other reasons include keeping a "warm" production base, and not having an identified requirement for a follow-on defense system.

Where to Obtain Information and/or Copies of Report

Anyone desiring more information about the report may call Professor Acker at (703) 664-4795 or Autovon 354-4795. Copies of the report may be obtained from the Defense Technical Information Center, Defense Logistics Agency, Cameron Station, Alexandria, Va. 22314, or by calling (202) 274-6847 or Autovon 284-6847. There is a charge for copies sent to contractors. Ask for ADA 127380.

Second Sourcing

A Way to Enhance Production Competition

There are potential benefits—and pitfalls—in using a second source to increase competition in a defense program. For the PM who makes such a decision, here are some methods to use and some variables to consider.

Commander Benjamin R. Sellers, SC, USN

In his memorandum accompanying Recommendation 32 of the Acquisition Improvement Program (AIP), Deputy Secretary of Defense Frank C. Carlucci said, in part:

> The value of competition in the acquisition process is one of our most widely accepted concepts. We believe that it reduces the costs of needed supplies and services, improves contractor performance, helps to combat rising costs, increases the industrial base, and ensures fairness of opportunity for award of government contracts. Despite our beliefs and efforts at furthering competition, there is a serious concern that our achievements are not adequate. Many in government and industry believe that we award too many contracts without adequate competition.

With this policy statement and similar statements of current and former DOD officials as background, it is not surprising to find that even a casual review of the regulations, instructions, congressional testimony, or literature relative to acquisition management reveals the universal popularity of the concept of competition. This commitment to competition stems from the widely held belief that better products are provided at lower prices in a competitive rather than non-competitive environment. The preference for competition, manifested by the requirement to generate differing designs and to select the one that best meets the government's needs (price and other factors considered), is heavily emphasized in the current acquisition management instructions.[1] In defense-related industries, especially aerospace and electronics, competition for large government contracts is particularly intense. Given the emphasis on competition in the instructions and evidence that intense competition does exist in the selection of new weapon systems, one might conclude that competition is alive and well in the Department of Defense acquisition process. But this is only partly true. The first phase of the acquisition process (design selection) is highly competitive. The second phase (production), however, where approximately 80 to 90 percent of total program acquisition costs are incurred, frequently involves no competition whatsoever when awarding the prime contract.[2]

That the Secretary of Defense is serious about increasing the amount of

competition was most recently asserted in a memorandum dated September 9, 1982, which received wide distribution throughout DOD. In his memo, Secretary Weinberger said, "The Department of Defense components are to place maximum emphasis on competitive procurement." He also emphasized that, "no type of purchase is automatically excluded from this direction [and that] particular attention should be given to those areas where the assumption traditionally has been made that competition is not available." Finally, he stressed that, "All personnel involved in the acquisition process from the first identification of the requirement through the execution of the purchase should recognize this responsibility."

In addition, DODD 5000.1 states that "effective design and price competition" is one of the primary acquisition management principles and objectives. Furthermore, DODI 5000.2 requires that the program manager specifically address his plan for competition in all phases of the acquisition life cycle in the Systems Concept Paper at Milestone I as well as in the Decision Coordinating Paper and the Integrated Program Summary at future Milestones.

The purpose of this article is to examine the potential benefits, as well as the potential problems, of generating a second source and of creating competition in the production phase of the acquisition process. In addition, five alternative methods of generating a second source (including the advantages and disadvantages of each method) are presented. Also, the variables that affect the selection of an appropriate second-sourcing method will be discussed and a heuristic model for making the selection will be provided. Finally, the author's conclusions and recommendations will be presented.

Background

The first phase of the acquisition process involves the design of alternative hardware/software systems to meet a recognized need. In this phase the government enjoys a high degree of monopsony power (one buyer—many sellers). Since weapon systems frequently have no counterpart in their commercial markets, the government can, to a large extent, dictate the terms and conditions under which the product selection will be made. Typically, several contractors are invited to participate in the design phase, each offering independent and competing alternative approaches to meeting the government's need. The reasons for, and the methods of, generating competition in the design phase of the acquisition process are addressed in considerable detail in the current instructions.

Contractors are generally willing, even eager, to participate in these design competitions because hundreds of millions, or even billions, of dollars in business (frequently in a sole-source environment) over an extended number of years is the reward for the contractor whose design is ultimately selected. Even for a contractor whose design is not selected, the benefits of participating in the design competition can be significant. This is because the development of alternative designs, often to the point of full-scale prototypes, may take several years and cost tens of millions of dollars for each design. This effort is funded by the government with relatively little risk to the contractors, because cost-reimbursement type contracts are normally used in this phase of the program. Considering the declining defense and aerospace business (in real dollars) during recent years, the excess capacity that exists in many defense-oriented companies, the need to retain experienced and imaginative engineering talent, and the enormous contracts waiting for the winner of the competition, contractors generally conform very strictly to whatever ground-rules the monopsonistically powerful government may impose.

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During the design phase, competition is usually intense. However, it should be noted that, although the estimated life-cycle cost of a particular system is a factor in the ultimate design selection, the selection is usually more heavily weighted toward the technical effectiveness of the competing designs, or the management and capacity considerations of the competing contractors, than it is to the estimated production and support cost of the proposed systems. Furthermore, it should be emphasized that the life-cycle cost estimates provided during the design competition are neither firm nor ceiling prices for future production of the system. They are simply "best guess" estimates. With the demise of Total Package Procurement, the winning contractor is no longer required to actually produce his proposed system within the estimated price. Design competition may therefore exert little, if any, influence on lowering the life-cycle cost of the competing systems. It has frequently been suggested that intense design competition may even raise the cost of the selected system through the "gold-plating" of the competing designs. The point to be made here is that design competition may indeed lead to development of better products, but it does not necessarily lead to lower prices.

The second major phase of the acquisition process, the production phase, begins when the selection of the winning design is made. It is during the production phase that competition may lead to lower prices. Until recently, however, there has been a lack of competition in this phase of the acquisition process. There is also a noticeable absence of guidance in the current systems acquisition instructions relative to the complex subject of competition in the production phase of the program. As a result, rather than taking steps early in the life of the program to provide for production competition, many program managers allow their monopsonistic power to disappear and, at the moment of source selection, they find that they are "locked in" to a sole source for the future production of their weapon system. The market situation at this point has changed from monopsony to bilateral monopoly—one buyer and one seller.

Having forfeited the beneficial influence of competition, the program manager is forced to rely on the negotiating skills of his contracting officer to obtain a fair and reasonable price for the procurement of the system. Furthermore, in the absence of effective production competition, the government attempts to protect its interests and create effective cost control through a variety of elaborate and cumbersome techniques such as: (1) the use of productivity-enhancing incentives; (2) the requirement for extremely detailed cost and pricing data under the authority of Public Law 87-653 (the Truth in Negotiations Act); (3) involvement in the contractor's make-or-buy decisions; (4) component breakout decisions; (5) the conduct of should-cost and design-to-cost studies; (6) the use of value-engineering change clauses; and (7) in the past, the services of the Renegotiation Board. If competition were present in the production phase, some of these techniques could be eliminated, as well as the thousands of pages of reports they require, because normal market pressure would force the contractors to maximize the efficiency of their operations while delivering high-quality products.

Potential Benefits of Second Sourcing

The two primary benefits of second sourcing are the cost savings that may result from production competition, and an expansion of the industrial base. Some additional benefits of second sourcing will be provided later.

With respect to the cost savings involved in competitive vs. sole-source procurement, a variety of statistics have been cited in the literature. One of the most frequently quoted studies was reported by Secretary of Defense McNamara in 1965, when he stated to the Joint Economics Committee of Congress that savings on the order of 25 percent or more generally resulted from a conversion to competitive procurement from sole source. Similar figures have been obtained by GAO.[3] A 1972 study performed by the Army Electronics Command reported average savings of 54 percent from the competitive procurement of several electronics equipments. This study also stated that "reasonable confidence could be attached to using at least a 40 percent reduction for planning purposes."[4] A particularly interesting example is provided in a report by David V. Lamm that indicates that a price reduction of more than 50 percent was realized when a sole-source producer of missile rocket motors discovered that the Naval Air Systems Command was merely initiating actions to develop a second source.[5]

When viewed with respect to the overall DOD procurement budget, these potential savings are truly dramatic. With a 1982 procurement budget of nearly $70 billion, every 10 percent increase that can be generated in production competition represents potential savings of between $1 and $2 billion per year (assuming the average net savings resulting from competition is between 15 and 30 percent).

It should be noted that not all programs will benefit to the same degree from the existence of production competition. The increased investment cost in terms of additional facilities and equipment, the cost of technology transfer, the negative influence with respect to economies of scale, and dilution of the learning curve resulting from sharing the production quantities among two or more producers, must be estimated if possible and compared to the savings anticipated from competition. This cost/benefit approach should be applied to each program in order to determine whether production competition is appropriate for the program.

With respect to expanding the production base, having two or more qualified producers provides protection against strikes, fires, acts of God, or other catastrophic failures of one contractor. In some cases, particularly for critical defense systems, this protection may be the main reason for establishing a second producer, even if it means the government has to pay a premium price. The Defense Acquisition Regulation (DAR) 3-216 addresses this subject in detail.

Potential Problems

There are several problems, or potential problems, associated with the generation of second production sources, such as:

—*Additional front-end costs*. There are additional tooling and start-up costs as well as technical data package and/or technology transfer costs associated with establishing a second source. In order for second sourcing to be cost-effective, the additional costs must be more than compensated for by reduced procurement and ownership costs.

—*Unwillingness of contractors to participate.* Difficulties may be experienced in securing the cooperation of the original developer or in obtaining offers from qualified second sources. This is particularly true when the system to be procured has extensive commercial as well as military applications.

—*Complexity.* Maintenance of the data package and coordination of engineering changes are more complicated when more than one contractor is involved in production of the system.

—*Dilution of the learning curve/economies of scale.* Dividing the production quantities among two or more sources reduces the beneficial effects of the learning curve and eliminates some economies of scale. However, if effective price competition is established, the result will be a downward shift and/or an increase in the slope of the learning curve, which will more than overcome the negative impact of "diluting" the learning curve.

These and other problems have been raised, suggesting that effective production competition may not be feasible or desirable. In my opinion, however, in the vast majority of cases, the problems can be either eliminated or minimized by proper advance planning, early and forthright communication with the contractors, and effective implementation of an appropriate second-sourcing method.

THE SECOND SOURCING METHOD SELECTION MODEL (SSMSM)

There are at least five techniques that are currently being used for establishing a second source for production of a weapon system. The process of deciding which, if any, of these techniques to use should follow a logical series of steps: (1) specific objectives to be fulfilled must be clearly stated and understood, (2) a determination must be made as to the adaptability of the project in question to second sourcing, and (3) the acquisition alternative that will best achieve the stated goals must be selected and effectively implemented. There are at least seven potential reasons for establishing a second source:

(1) Broadening the production phase;

(2) Evening out the fluctuation in the defense industry, which leads to feast or famine situations for individual firms;

(3) Achieving superior equipment through increased competition;

(4) Achieving savings through increased competition;

(5) Facilitating NATO participation as co-producers or through offsetting co-production as subcontractors;

(6) Facilitating the attainment of socio-economic goals by increased award to minority and small business contractors; and

(7) Disengagement of some government controls in the contractual relationship.

It is fully conceivable that some of these objectives may, in fact, be in conflict. If such is the case, a determination must be made as to the relative importance of the objectives so that those having the greatest impact may be considered as controlling.

Once the reasons for second sourcing have been established, this section presents a model which may be used by the program manager and/or the contracting officer in determining: (1) whether or not the generation of a second source is feasible, and (2) which second-sourcing methodology is best suited to the given acquisition situation. The Second Sourcing Method Selection Model was developed jointly by myself and Commander Dennis S. Parry, SC, USN.

The following topics will be discussed in the remainder of this section: methods of generating a second source; variables affecting the second-sourcing decision; and the model itself—including its format, the rationale behind the effectiveness factors incorporated therein, and a discussion of the actual use of the model.

Methods of Generating Second Sources

This section discusses five methods that can be used to provide a second source for production of a weapon system. Each method has advantages and disadvantages. The five methods to be described in the following pages are form-fit-function; technical data package; directed licensing; leader-follower; and contractor teams. It should be emphasized that, where possible, the decision of whether or not to pursue second sourcing should be made early as possible in the life of the program so that the development contracts can be structured to facilitate the technology transfer so essential to production competition. If the program manager waits until the design selection is made to consider production competition, he will probably encounter stiff and possibly insurmountable opposition from the "other half" of the bilateral monopoly he has created.

Form-Fit-Function (F^3)

This method involves introduction of a second production source without need for a technical data package or for interaction between production sources. The second source is provided with functional specifications regarding such parameters as overall performance, size, weight, external configuration and mounting provisions, and interface requirements. This is the classic "black box" concept, where it is not necessary to define the internal workings of the product. It is used frequently for the acquisition of expendable, non-repairable items where the ability of the system to perform as required is not dependent on what is inside the "box." The method does not work well where field-level maintenance of the system is envisioned, since the provision of non-identical items makes stockage of repair parts and training of maintenance personnel potentially *insurmountable problems.* These objections sometimes can be overcome by the use of warranty provisions, renewable maintenance contract provisions, and/or provisions for contractor services to set up the necessary government maintenance capabilities to support the equipment throughout its lifetime. The advantages of acquisition by F^3 specifications include the following:

—Detailed design responsibility is clearly assigned to the contractor. If the items fail to meet specifications, the contractor must alter the design until specified operation is achieved.

—There is no design data package for the government to procure or maintain.

—Requirements for technical capability within the government are minimized. This is the path of least involvement on the part of the government in contracting, contract monitoring, etc.

—Standardization can be achieved among multiple sources through two-

way interchangeability of products that may differ internally. These multiple sources may be exercised simultaneously.

The disadvantages include the following:

—Each procurement contains a development effort unless the product is off-the-shelf modified. Some time and money are involved each time the item is procured for engineering, changes, production learning curves, and debugging.

—Each time a procurement is made, the contractor who has the least appreciation for the total significance of the specification and the effort to accomplish the task is likely to be the low bidder. This means the source-selection criteria must be very carefully constructed to include mechanisms to demonstrate contractor awareness of critical elements as well as his capabilities to produce the item.

—The costs of repair parts will tend to become excessive when a contractor realizes that he is in a somewhat sole-source position with respect to his equipment, unless the total maintenance of the service life of the equipment is provided for in the procurement contract while competition is still being maintained.

—Careful specification of all external parameters and interface requirements is required to ensure true interchangeability.[6]

—This approach has significant drawbacks if there is instability in the performance or interface requirements of the system being procured.

Technical Data Package (TDP)

This method involves utilization of a stand-alone technical data package to solicit proposals from manufacturers who may not have been involved in the initial development of the system or in initial production. Ordinarily, this is accomplished through the invocation of an appropriate data rights clause in the original R&D or initial production contract. Even where no such clause exists, it may be possible to buy the data package subsequent to production. In the absence of such a clause, the original developer/producer may consider the design, or portions of it, to be proprietary, and hence may be reluctant to provide a complete TDP to the government. The cost of procuring the data package subsequent to initial production may thus be prohibitive. This method assumes that the data package alone is sufficient to allow production of the system by alternative manufacturers. Although this technique has been used successfully, there are frequent examples where significant difficulties have been faced in applying it. Its chief attraction is that the existence of an adequate data package can result in the maintenance of a competitive environment throughout the life of the project.

Although theoretically sound, this method is perhaps the most hazardous of all the second-sourcing methodologies. It is not well-suited for use in highly complex systems or systems with unstable design or technologies. Experience has shown that drawings and specifications alone are often insufficient to secure effective transfer of manufacturing technology. "The critical factors may be craftsmen's skills, ingenious processes, 'tricks of the trade,' and esoteric shop practices that cannot be reduced to formal or informal paper."[7]

Once the data package has been accepted from the developer, the government effectively guarantees its accuracy and adequacy to the second source. If defects are subsequently discovered in the TDP, as is almost always the case, the second source may have the basis for a claim against the government. Some methods of minimizing this particular problem include requiring the producer of the data package to certify its adequacy; preproduction evaluation by the second source, and the use of latent/patent defects clause in the contract with the second source, to name a few. However, it has been maintained by many legal representatives that the mere existence of a latent/patent defects clause is tantamount to governmental acknowledgment of the inadequacy of the package. This puts the government in a precarious legal position in the event of subsequent claims.

There are other problems associated with the TDP approach. Although there are those who maintain that if the system is developed under government contract, there should be no proprietary rights to any of the data, the fact remains that much of the data required for successful technology transfer may be encumbered with claims that the information is proprietary. These problems center on the definition of "proprietary data" and "trade secrets" and on whether or not the government has the right to require the dissemination of such information. A complete discussion of these questions is beyond the scope of this article; however, they are discussed in detail in a Rand Corporation report by James W. McKie entitled "Proprietary Rights and Competition in Procurement." A 1975 report of the National Materials Advisory Board of the National Academy of Sciences entitled "The Effectiveness of the Army Technical Data Package in Technology Transfer for Procurement" provides valuable information regarding the use of the TDP as a vehicle for generating production competition.

The major advantages of second sourcing via the TDP include:

—The TDP can be used repeatedly in maintaining a competitive atmosphere throughout the production phase of the acquisition.

—Once the TDP is validated and proved adequate for production of the system, the mechanics of second sourcing are relatively simple. There need not be any contact between production sources, and it is even possible to eliminate the original source altogether.

The primary disadvantages of the method are as follows:

—It may be exceptionally difficult to obtain a complete and accurate TDP that is free of encumbrances and that, when followed, will yield a qualified product.

—The procuring authority must have access to whatever "in-house" talent is necessary to ensure resolution of data package problems.

—Even where drawings and specifications are complete and accurate, transfer of complex technology is often impossible without the benefit of engineering liaison between sources of production.

—Technological differences between companies (e.g., differing process methodologies) may be such that the second source does not have the capability to perform in accordance with the data package.

Directed Licensing (DL)

In its pure form, this method involves the inclusion of a clause in the early development contract allowing the government to reopen competition for follow-on production, select a win-

The mere threat of competitive options may be sufficient incentive for the developer to keep costs down.

ner, and appoint him as a licensee. Then, in return for royalty and/or technical assistance fees, the licensor (development contractor) will provide the licensee with manufacturing data and technical assistance to help the second source become a successful producer.

As used in some current acquisitions, licensing agreements also are being negotiated where no provision for such an agreement was included in the development contract. Such arrangements may, however, be considerably more costly than those specified in the original development contracts. There also has been a trend toward allowing the licensor to choose his own licensee—subject to government approval.

This method involves not only the transfer of data from the developer to the second source, but also provides for the transfer of manufacturing "know-how." The developer is normally awarded the first production contract and is contractually bound to licensing another contractor for production of an unspecified number of future systems. In fact, the provisions of the licensing agreement (including royalty fees, if any) should normally become one of the source-selection criteria used in choosing the winning developer. The original developer is thereby incentivized to minimize his proposed costs for technology transfer in order to keep his overall cost competitive.

Directed licensing seeks to solve technology transfer problems associated with the TDP methodology by providing for necessary engineering and manufacturing liaison between the sources. It derives its attractiveness from the fact that subsequent reprocurements can be competed—in whole or in part—even where complex systems technology is involved. The technique of commercial licensing has been used successfully in industry for years, especially by firms desiring the sale of their products in foreign markets. In fact, more than 10,000 aircraft have been manufactured by companies that were not involved in the original R&D work.[8]

As promising as directed licensing may appear, it may entail the incursion of significant identifiable costs. If the royalty fee is unreasonable, the benefits of competing the production buy will be significantly reduced. If the developer can provide an acceptable product at a lower price than could a second source, however, the government need not actually exercise the licensing option. The mere threat of competitive options may be sufficient incentive for the developer to maintain efficiency and keep costs to a minimum.

For a more detailed discussion of directed licensing, see the Rand Corporation report by Gregory A. Carter entitled "Directed Licensing: An Evaluation of a Proposed Technique for Reducing the Procurement Cost of Aircraft."[9] In 1969, the General Accounting Office (GAO) performed an evaluation of the feasibility of implementing directed licensing. The resultant report cites several potential problems with the technique and concludes that directed licensing would not provide a workable solution to the problem of reducing the cost of major systems.[10] The potential problems cited by GAO are addressed in the Carter article and are considered critical to understanding and evaluating and the potential effectiveness of directed licensing.

The advantages of directed licensing include:

—The potential for production competition is maintained throughout the acquisition cycle.

—The government need not become closely involved with the actual transfer of technology between sources.

—Quantity production decisions and source of supply decisions can be postponed until later in the acquisition process.

—The designer is provided with protection as to how, or in what markets, the second source is to be licensed to sell the product, and the designer may be compensated for each item produced by the second source.

The disadvantages of directed licensing include:

—The existence of royalty and technical assistance fees increases the cost of the acquisition and could be prohibitive.

—It may be difficult to achieve the necessary degree of cooperation between alternative production sources, and the licensee may have little recourse against half-hearted cooperation on the part of the licensor.

—Some contractors may bid on projects simply to obtain proprietary information on other producers' designs.

—It may become difficult to maintain design accountability.

Leader-Follower

The DAR defines leader-follower as "an extraordinary procurement technique under which the developer or sole producer of an item or system (the leader company) furnishes manufacturing assistance and know-how or otherwise enables a follower company to become a source of supply for the item or system." The DAR limits the use of this technique to situations when all of the following conditions are present:

—The leader company possesses the necessary production know-how and is able to furnish requisite assistance to the follower;

—No source of supply (other than a leader company) would be able to meet the government's requirements without the assistance of a leader company;

—The assistance required of the leader company is limited to that which is essential to enable the follower company to produce the items; and

—The government reserves the right to approve contracts between the leader and follower companies.

The DAR suggests the following three methods for establishing a leader-follower relationship (no preference is indicated as to which should be used):

One procedure is to award a prime contract to an established source (leader company) in which the source is obligated to subcontract a designated portion of the total number of end items required to a specified subcontractor (follower company) and to as-

sist the follower company in that production.

A second procedure is to award a prime contract to the leader company for the requisite assistance to the follower company, and another prime contract to the follower company for production of the item.

A third procedure is to award a prime contract to the follower company for the items, under which the follower company is obligated to subcontract with a designated leader company for the requisite assistance.

Leader-follower procurements have been undertaken in the past more for the purpose of meeting delivery schedule requirements owing to the lack of capacity of a single source, rather than for increasing competition. However, since the concept encompasses dual or parallel production lines, splitting the award quantity on a high-low percentage basis would still ensure a significant degree of competition for the annual production contracts.

The advantages of leader-follower are similar to those of directed licensing in that:

—It provides a technique for transferring part or all of the production or a complex system to a second source.

—Competition can be utilized to determine the acquisition split award to each qualified producer even when two sources are maintained throughout the acquisition cycle.

—It has been used successfully in the past.

The major disadvantages of the leader-follower technique are that "leader" companies may be less enthusiastic about this technique than directed licensing because leader-follower contains no royalty provisions for proprietary data, nor does it provide some of the protection that may be present in a licensing arrangement.

Contractor Teams

A recent innovation in the generation of production competition is represented by the contractor teams that competed in the design-selection phase of the Airborne Self-Protection Jammer (ASPJ) system. In the solicitation for the design of the ASPJ, the Naval Air Systems Command (NAVAIR) required that offerors form teams of two or more contractors. This acquisition strategy envisions the award of a production contract to the team that eventually wins the design competition. During initial production, both contractors are required to demonstrate the capability to produce the complete system. The DAR provides a brief discussion of contractor teams, including a policy statement on the use of teaming arrangements. The implication of the DAR is that the government will generally permit contractor teams, but it does not mention actions by the government to require the formation of teams as was done on the ASPJ. The DAR does mention that some contractor-teaming arrangements may violate antitrust statutes. The program manager and/or the contracting officer must be sensitive to this possibility in order to prevent its occurrence.

The advantages of requiring contractor teams are as follows:

—It should prevent most of the problems in qualifying a second source, since at least two contractors were involved in the design and initial production.

—It should reduce or eliminate the feeling on the part of either contractor that trade secrets or proprietary data are being given away to outside sources.

—No liaison fees or royalties will be involved in the establishment of the second source.

—The design talent of two contractors will be brought to bear on each proposal, thereby increasing the opportunity for successful and innovative designs.

—It provides a vehicle for increasing the capacity of the industrial base.

The disadvantages of contractor teams are that:

—The design phase may be more costly, since at least two contractors are involved on every proposal.

—It requires a great deal of cooperation and coordination by the contractors.

Variables Affecting the Production Competition Decision

The selection of the "best" method for generating production competition will vary depending on a number of factors extant in any acquisition program. The existence of these factors (i.e., decision variables) presents the program manager with a difficult, multifaceted decision situation. He must consider the strengths and weaknesses of each competitive method in relation to the influence of the variables in his acquisition program.

In order to assist the program manager in logically and systematically selecting the optimal competitive method, an evaluative model is needed. The model should rank each of the competition techniques against each of the decision variables. Then, by objectively evaluating the influence of each of the variables, the program manager will be led to an optimal choice of which method of competition to use in his program. At a minimum, one or two methods may be shown to be clearly superior to the others, thereby reducing the complexity of the decision situation.

The next section presents such a model. Before describing the model, however, it is necessary to define the decision variables on which the model is based and to describe the general impact which each of the variables has on the feasibility of production competition.

Second Source Decision Variables

Quantity to be Procured

The ultimate quantity to be procured and the rate at which the government will place orders for production will have a significant effect on the adaptability of the project to second sourcing. In general, the larger the quantity to be procured, the more feasible it is to have production competition. The ideal situation for second sourcing will entail large quantities needed at a rapid rate over a number of years. Any deviation from this ideal will tend to lessen the cost effectiveness of generating a second source.

Duration of Production

As alluded to above, it is generally true that the longer the duration of the projected production, the more feasible second sourcing becomes. For example, suppose the production phase is to be only 4 years long, and it takes at least 2 years to bring a second source on line (including source selection, start-up of the plant, and production of a learning/qualification quantity). In this case, there would be only a year or so left for production of the system by the second source, in which case second sourcing would be an inappropriate strategy.

If the system has wide applicability for other government or commercial uses, the original developer is more likely to demand protection for his trade secrets.

Slope of the Learning Curve

The flatter the slope of the learning curve, the more adaptable the project becomes to second sourcing. With a steep learning curve, the more units produced by the original source before a second source is brought "on-line," the more unlikely it becomes that the second source can effectively compete with that original producer who is, by then, a more experienced and efficient producer.

Complexity of the System

The more complex the system, the more essential is the need for cooperation and liaison between the two production sources, and the less adaptable is the project to second sourcing.

State-of-the-Art

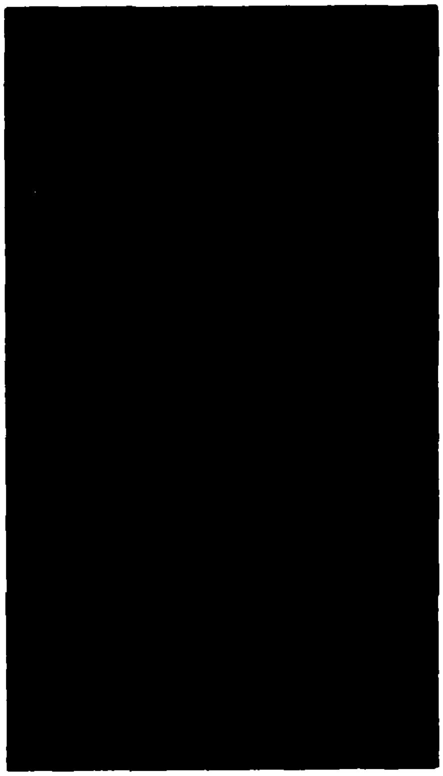
If the technology employed in the system is at the leading edge of (or advances) the state-of-the-art, it becomes unlikely that a second source will be able to produce the system without significant difficulties—probably necessitating significant cooperation between original and second-source producers.

Other Potential Government or Commercial Applications

If the system has wide applicability for other goverment or commercial uses, the original developer is more likely to demand some form of protection for his "trade secrets" or "proprietary data" than if the market for the product is very limited. On the other hand, the interest of potential second sources in the project will be stimulated if other applications for the hardware exist.

Degree of Privately Funded R&D

The greater the degree of privately funded R&D on which the design is based, the more reluctant the developer will be to release his design to a second source. This is particularly true



if no restrictions are placed on the use of the design by that second source.

Cost of Unique Tooling/Facilities

As special tooling/facilities requirements and costs increase, the number of potential second sources decreases and the probability of being able to bring a second source on line in a cost-effective manner decreases. Also pertinent will be other start-up and nonrecurring costs, including first article acceptance testing. The higher these costs become, the more difficult it is to amortize them over the duration of the acquisition.

Cost of Transferring Unique Government-Owned Tooling/ Equipment

If any unique government-owned tooling is difficult or expensive to transfer from one contractor to another, it may be necessary to provide duplicate sets of tooling in order for a second source to become a viable competitor. The cost of transferring tooling, then, can work in the same manner as the cost of the tooling itself in inhibiting the adaptation of the project to second sourcing.

Contractor Capacity

If the original producer does not have the ability to produce needed quantities of the system according to the required delivery schedule, development of a second source may become mandatory. Lack of adequate capacity may thus be considered a controlling factor in deciding for second sourcing. If, on the other hand, the original producer has sufficient or even excess capacity, reduction in the production quantities award may significantly increase the costs of production through increased overhead.

Maintenance Concept to be Employed

Second sourcing, with its multiple producers, can have significant impact on the maintenance considerations of the system. Whenever two systems of the same type are non-identical, the ability to support those systems with field-level repair parts and maintenance personnel becomes more difficult and more costly.

Production Lead Time

The longer the production lead time, the longer it will take to bring a second source in line and the less appealing becomes the second sourcing option.

Amount and Type of Subcontracting

If the number of qualified subcontractors is limited, and the degree of reliance on those subcontractors is necessarily heavy, the benefits to be realized through second sourcing are necessarily lessened.

Contractual Complexity

The more complex the original production contract (e.g., life-cycle cost parameters, design-to-cost considerations, warranty agreements) the less adaptable to second sourcing the project becomes. With warranties, for instance, it may be necessary to keep two sources capable of performing warranty work throughout the life of the project—even though a production buyout may have been exercised at some point in the acquisition.

The Model

The Second Sourcing Method Selection Model shown on the following pages is heuristic in nature. Its objective is to provide a logical and systematic framework for evaluating the applicability of each of the competitive methods in light of the variables present in the acquisition situation. The end result of the evaluation process will (at best) be the selection of the optimal competitive technique. At worst, use of the model should serve to eliminate one or more techniques from further consideration. In that case, the decision situation will have been simplified and certain variables should emerge as being critical, thereby suggesting the areas that need further investigation and consideration. The potential user of this model is cautioned that it has not been validated in actual use. Rather, it represents the best judgment of its authors, based on research and interviews, of the factors that affect the second-sourcing decision.

Format of the Model

It should be noted that the model is actually two models. The preproduction model (Figure 1) is for use by the program manager who is developing his overall acquisition strategy. In other words, the program second-sourcing decision is being made at some point prior to DSARC II. The post-production model (Figure 2) is for use by a program manager who is already in the production phase of the program and is considering the generation of a second source for part or all of the remaining life of the acquisition. It is necessary to differentiate between the two situations, because the effectiveness factors assigned to each of the methods change significantly depending upon whether the second-sourcing decision is being made early or late in the program's life cycle.

		Methodology				
Variables		**F³**	**TDP**	**DL**	**L-F**	**CT**
	High	+	+	+	+	+
Quantity	Medium	+	+	0	0	+
	Low	0	0	–	–	0
	Long	+	+	+	+	+
Duration	Medium	+	+	0	+	+
	Short	0	0	×	×	0
Learning	Steep	–	–	–	0	0
Curve	Flat	+	+	+	+	+
Technical	High	0	×	+	+	•
Complexity	Medium	+	–	+	+	+
	Low	+	+	+	+	+
State of	Yes	0	×	+	+	•
the Art	No	+	+	+	+	+
Other	Yes	+	0	+	0	+
Application	No	+	+	+	+	+
Degree of	High	0	×	0	×	–
Private R&D	Low	+	0	+	+	+
Tooling	High	–	–	–	–	×
Costs	Low	+	+	+	+	+
Govt. Tool	High	0	0	0	0	0
Transfer	Low	+	+	+	+	+
Cost						
Contractor	Excess	–	–	–	–	–
Capacity	Deficient	+	+	+	+	+
Maintenance	Significant	×	0	0	0	0
Requirement	Minimal	+	+	+	+	+
Production	Long	–	–	–	–	–
Lead Time	Short	+	+	+	+	+
Degree of	Heavy	0	–	–	–	–
Subcontracting	Light	+	+	+	+	+
Contractor	Complex	–	–	–	–	–
Complexity	Simple	+	+	+	+	+

The SSMSM lists the 14 decision variables vertically on the left. Each of these variables is divided into two or three categories (e.g., high-medium-low, yes-no) to allow the model to be tailored to the refinements of a given acquisition. Across the top of the model are listed the second-sourcing methodologies. It should be noted that the five methods (F^3, TDP, DL, LF, and CT), when placed in that order, represent a line of continuum with respect to the degree of cooperation and contact needed between the original developer and the second source. For example, second sourcing on the basis of F^3 or TDP involves no need for contact between the two contractors. At the other extreme is CT, which represents a formal alliance between two or more contractors. Recognizing this relationship among the methods provides a better understanding of the way each method relates to the variables and to the other methods. Understanding this relationship may even lead to effective modification or hybridization of the techniques not previously considered.

Variables		Methodology				
		F^3	TDP	DL	L-F	CT
Quantity	High	+	+	+	+	+
	Medium	+	0	0	0	0
	Low	0	×	−	−	−
Duration	Long	+	+	+	+	+
	Medium	+	0	0	0	0
	Short	0	×	×	×	−
Learning Curve	Steep	0	0	0	0	0
	Flat	+	+	+	+	+
Technical Complexity	High	0	×	+	+	+
	Medium	+	−	+	+	+
	Low	+	+	+	+	+
State of the Art	Yes	0	×	+	+	*
	No	+	+	+	+	+
Other Application	Yes	+	−	+	0	+
	No	+	0	+	+	+
Degree of Private R&D	High	0	×	0	×	0
	Low	+	0	+	+	+
Tooling Costs	High	−	−	−	−	×
	Low	+	+	+	+	+
Govt. Tool Transfer Cost	High	0	0	0	0	0
	Low	+	+	+	+	+
Contractor Capacity	Excess	−	−	−	−	−
	Deficient	+	+	+	+	+
Maintenance Requirement	Significant	×	0	0	0	0
	Minimal	+	+	+	+	+
Production Lead Time	Long	−	−	−	−	−
	Short	+	+	+	+	+
Degree of Subcontracting	Heavy	0	−	−	−	−
	Light	+	+	+	+	+
Contractor Complexity	Complex	−	−	−	−	−
	Simple	+	+	+	+	+

Effectiveness Factors

The model rates the effectiveness of each of the methods with respect to each of the decision variables. A simple three-point system of "+," "0," or "-" is used to denote whether a given method is particularly strong, neutral, or weak with respect to each of the variables. In addition, an "X" is used to denote a situation where the use of a given method is particularly inappropriate, or to caution that particular care should be used in applying a given method in that situation. An asterisk, on the other hand, indicates that the method is particularly well suited to the situation under consideration.

The three-point system is used because of the non-quantifiable nature of the model. A numerical scale (-5 to +5, for example) would merely invite argument over the rankings assigned and would detract from the main purpose of the model. The primary value of the model is that it serves as a guide to the subjective decision process and that it gives recognition to the differences among the methods. It is not intended to provide an elaborate quantification scheme which removes the need for experience and judgment.

Discussion of the Model's Weighting

Quantity

Low production quantities make successful second sourcing difficult, at best. None of the methods will work well under such circumstances. By the time the second source is qualified as a producer, the savings potential on the remaining quantities will probably not justify the associated expense. In the post-production phase, the difficulties usually associated with the qualification of a second source through the use of a TDP make that method especially undesirable, whereas the relative simplicity of the F^3 technique yields the greatest probability of success when low quantities are involved. Only where the magnitude of the system and its price are truly significant will small quantities justify the use of the DL, LF, or CT methods. As quantities rise; the viability of all the methods increases. Because there is a dilution of the total quantities to be produced subsequent to initial production, the pre-production portion of the model appears slightly more favorable than the post-production portion with respect to quantity.

Duration of Production

The rationale provided in the discussion on quantity also pertains to the duration-of-production variable. Any attempts to qualify a second production source will take time, and the likelihood of success decreases as the time required for the qualification of a second source increases. Directed licensing and LF techniques are therefore especially unsuitable for systems with short production lives since both assume original production by the development contractor.

Slope of the Learning Curve

If the demonstrated learning curve of the original producer is flat, all methods are worthy of consideration. Where steep learning is exhibited, the original producer will experience a significant competitive advantage for future awards, and if cost saving is the object of a second sourcing effort, it may be extremely difficult to justify

going to an alternative source. It should be noted, however, that a steep learning curve might also indicate that the base price was unrealistically high in the first place—resulting in an unjustifiably inflated original award. It also should be recognized that the existence of price competition should result in an increase in the slope of the learning curve for both producers.

Technical Complexity

Directed licensing, LF, and CT are techniques that are designed to provide the necessary liaison and cooperation to assure effective transfer of even highly complex technology. Contractor teams are especially effective under such circumstances, since the teams can be constituted so that complementary technologies can be brought together. When production by an original source has begun, CT, in the pure sense, is not possible; however, a team of competitors might be attracted to vie for follow-on production contracts. Problems with TDPs are often insurmountable without costly and labor-intensive effort when high levels of technology are involved. It is not impossible to use this method in such cases; however, extreme care must be exercised to ensure the adequacy of the data package and to ensure the choice of a second source which is likely to be capable of overcoming data package problems. The simpler the system, the more probable becomes the success of all the methods.

State-of-the-Art

The same rationale for the technical complexity factor applies to the state-of-the-art variable. The more liaison between the production sources, the greater is the chance of successful technology transfer. Transfer of state-of-the-art technology by data packages alone is virtually impossible.

Other Government and Commercial Applications

Where there are expected to be significant alternative uses for the system, the original producer may be expected to claim or generate legal or quasi-legal barriers (patents, trade secrets, proprietary data) to the dissemination of his design unless he is handsomely compensated, or is given specific protection in the form of limitations placed on the use of his design. Directed licensing provides royalty payments to the developer/original producer; F^3 does not require the transfer of data; and CT arrangements specify that both members of the team will be capable of producing the end item so these methods facilitate the award of alternate follow-on production contracts. With a TDP, the post-production use of the method is less attractive, since the original producer will usually have proof of alternative uses rather than conjectured alternatives.

Degree of Privately Funded R&D

If the contractor's privately funded R&D leads to the development of a design that the government selects for production, it is almost certain that a significant amount of proprietary data will be included in the design package. In such a circumstance, he is likely to vehemently resist any attempt to disseminate that information. With DL and CT methodologies, his rights will be protected, or he will receive compensation for the use of his data so his resistance will be somewhat less adamant. Although it is difficult to imagine a situation wherein all the R&D would be privately funded, the existence of a single critical process that is truly proprietary will greatly lessen the chance of second-sourcing success.

Special Tooling Costs

When the cost of special tooling is significant, the willingness of potential competitors to enter the market—without provision of government-owned tooling or unless the quantity and duration of production is sufficient to allow amortization of the costs of such tooling—is limited. Regardless, the original producer will have a real competitive advantage where high tooling costs are included. Even where the tooling is government-owned, the potential disruption associated with the transfer of the tooling may be unacceptable—requiring that duplicate tooling be provided. A contractor teaming arrangement, subsequent to initial production, might result in the need for three separate sets of tooling—making such an arrangement particuarly unpalatable.

Cost of Transferring Unique Government-Owned Tooling

Shifting of production units from one source to another implies one of two alternatives; (1) shifting the government-owned tooling, or (2) providing additional—perhaps excess—capacity in the form of duplicate tooling and equipment. Of course, where mobilization base considerations are controlling, the latter is mandated. Also, where the cost of buying duplicate tooling is less than or equal to the cost of transferring the tooling from year to year (including disruptive costs), this variable may be eliminated from consideration. Since the cost of transferring tooling and equipment has an equal affect on all methodologies, the weighting assigned to each is identical.

Capacity of the Developer/ Original Producer

When the original producer does not have sufficient capacity to allow him to manufacture the desired system in required quantities, at required quality, and to deliver those systems in accordance with the prescribed schedule, any of the methods may be considered. Where sufficient or excess capacity exists with the original producer, it may be more costly (especially in the short run) to second source than it is to remain with the original source alone. Cutting the quantities awarded to a source, with existing excess capacity, usually means that the fixed overhead must still be spread over the now lower quantities—yielding higher prices.

Maintenance Requirements

Where field-level maintenance needs are relatively insignificant, second-source production presents little or no problem. As the need for field maintenance increases, however, the non-identical nature of second-source systems becomes more difficult to accommodate. Form-fit-function systems usually exhibit the least degree of commonality and therefore cause the most severe maintenance and support problems.

Production Lead Time

The longer the lead time associated with the production of the system, the more difficult it becomes to bring alternative producers on line early enough to realize the potential advantages of second sourcing. This holds true regardless of the second-sourcing method chosen.

Contractual Complexity

The more complex the contractual relationship between the original pro-

The program manager must understand what constitutes effective competition in both the design and production phases of his program.

ducer and the government, the greater are the barriers to successful second sourcing. Life-cycle cost parameters, reliability-improvement warranties, and other contractual complexities become difficult to enforce when dealing with multiple sources. In fact, the cost of maintaining multiple-source warranties may become prohibitive.

Degree of Subcontracting

Where there is a great deal of subcontracting, or where the number of firms capable of performing subcontracting functions is limited, the advantages of second sourcing the prime contract will be diluted. Given the fact that the primes may be forced to compete for the services of the same subcontractors, or use the materials of a single supplier, the prices may even rise with second sourcing.

Use of the Model

As stated earlier, the model is not designed to be a strictly quantified decision-making device wherein the evaluation factors for each method are summed and the method with the highest "score" is selected. The correct use of the model requires the use of judgment at every step. The first (and possibly most difficult) step is to evaluate the acquisition situation in terms of the decision variables (that is, to determine whether the acquisition will cover high, medium, or low quantities; whether technical complexity is high, medium, or low; and to make similar judgments about the other variables). The program manager is encouraged to add new variables to the list as he sees the need for them. The next step is to evaluate the second-sourcing methods in relation to the variables that exist in a program—realizing that some variables will be more important than others. One method may turn out to dominate all the others or there may be more than one feasible method. Additional judgment will, therefore, be required. It may even be possible to allow the competing contractors to have an input to the decision process. If the model can simplify and guide the thought process so that (1) all significant variables are recognized and objectively evaluated; (2) clearly inappropriate second-sourcing strategies are eliminated; and (3) an appropriate method is selected, then the model will have served its purpose.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from the research:

It is clear that the concept of competition enjoys a high degree of support from a wide range of advocates. In order to successfully incorporate competition into an overall acquisition strategy, however, the program manager must understand what constitutes effective competition in both the design and production phases of his acquisition program.

The current acquisition instructions address the subject of design competition in considerable detail. The instructions specify the reasons for, and the general approach that should be taken in, the generation of design competition. However, no guidance is provided as to the advantages or problems associated with obtaining a second production source, the methods available for generating a second source, or the decision-making process by which a second-sourcing method should be selected.

Second sourcing may not be appropriate for all acquisition programs, particularly those with short production lives and/or low production quantities. However, where it is feasible, the establishment of a second source may provide substantial benefits to the government, such as:

—Broadening the production base.

—Cost savings from production competition, possibly in the billions of dollars per year.

—Smoothing out the fluctuations in the defense industry that lead to feast-or-famine situations for individual firms.

—Achieving superior equipment through increased competition.

—Facilitating NATO participation as co-producers or through offsetting co-production as subcontractors.

—Facilitating the attainment of socio-economic goals by increased award to minority and small business contractors.

—Reducing the propensity for buy-ins.

—Disengagement of some government controls from the contractual relationship.

Decisions regarding both design and production competition should be made as early as possible in the acquisition cycle and incorporated as an integral part of the acquisition strategy.

Contractors should be informed early in the process of the government's intentions relative to both design and production competition.

Particularly worthy of note is the fact that the cost-saving potential of production competition may be achieved without actually having to bring a second source on-line. The mere existence of a viable method of transferring part or all of the production to a second source may be sufficient to ensure that the original producer strives for maximum efficiency while providing a high-quality product.

The generation of a second source, for whatever reason, has several problems or potential problems associated with it, such as:

—Additional front-end costs;

—Willingness of contractors to participate;

—Potential for unqualified contractors to buy-in and subsequently to default;

—Program stretch-out; and

—Maintenance of the data package/coordination of engineering change proposals.

(continued on page 31)

Unified System Effectiveness Analysis and Control

A Way to Battle Cost and Unreliability—and Win

Bud Dworkin

The complexity of the evolution of a modern weapon system in democratic America is of phenomenal proportions. The fact that a system ever reaches an operable state, even with shortfalls in effectiveness and overruns in cost and schedule, is a tribute to this country's genius in management and technology, as well as to our past ability to pay a very high price. But with systems that are displaying both unacceptable costs relative to the national economy, and ineffectiveness relative to the threat, the point has already passed where forced corrective actions from outside the defense community may be expected with increasing frequency and impact.

Suggestions and initiatives for improving this situation have been wide-ranging and include the latest package of 32 Acquisition Improvement Program actions.

This article addresses a technique, not knowingly incompatible with any of these initiatives, that is designed to help relieve the problems of cost overruns and system/cost ineffectiveness. The concept involves the use of a unified Systems Effectiveness Analysis and Control (SEAC). In regard to cost, the proposed SEAC concept will help minimize the roughly 83 percent of other-than-inflation overruns in recent years due to changed requirements and the 17 percent due to errors in estimating a program's costs. This will be done by providing increased visibility for decision-makers through better technical definitions and control, which will, in turn, enable a better adherence to established baselines and enhance the effectiveness of our disciplined management systems. High supportability costs are expected to be reduced by establishing, as a critical top-level measure of effectiveness, the dollar value limit within which the mission-related capability must be provided over the system's life cycle. Thus, an effort may be made to bring some long-overdue innovations to the total support cost monster, and to stop perpetuating reliability as the sole scapegoat. The SEAC concept will not directly relieve the problem of inflated unit costs, but by helping to greatly improve the operational readiness of a new system, the total number of units to be bought is naturally reduced.

System effectiveness problems are difficult to address in consistent quantitative terms. The K051 reporting system at the Air Force Logistics Command, with the quarterly abstracts from each of its Air Logistics Centers, provided the best available source for such a perspective. Admittedly, controversial aspects of their raw data sources and processing can be found, but nothing better is available. In 1981 I analyzed data covering the first three quarters of 1980 for 17 fleets of first-line aircraft in the Air Force. Last year, I did the same for 25 fleets, spanning their experience in the first three quarters of 1981. This coverage accounted for an inventory of 5,504 aircraft with an average of 28 hours of flight per month per aircraft and a corresponding average logistic support cost (LSC)[1] of $709.35 per flight hour. In each of the two analyses, it was surprising to find the reliability factors looking so good and the operational readiness and support costs looking so bad. Only two of the 25 fleets had slightly better than 70 percent alert availability; seven were in the 40-50 percent range; ten were in the 50-60 percent range; and six were between 60 and 70 percent. Flight reliability, representing the percentage of unaborted sorties, showed eight between 0.98 and 0.99 and seventeen better than 0.99. In logistic support costs, the best three, the E3A AWACS, A-10A, and C-130B, had logistic support costs of $300-$400 per flight hour; the highest one among the 25 fleets exceeded $2,400; eight others were above $1,000. Tables I and II are provided to show these and a series of other system effectiveness parameters as they apply fleetwide for each of the indicated 25 aircraft during the period of January through September 1981.

This is obviously not a comprehensive effectiveness experience base, but a more detailed analysis is not particularly pertinent here. The important point to be made is that, as in the case of cost overruns discussed above, the system effectiveness shortcomings will be driven toward minimization by SEAC. This will follow from the better planning, programming, and control to be responsibly applied at the system program management level. This will be a consequence of the integration and evaluation within a common framework of mission-related system and program objectives, design implementations, and resource allocations.

The SEAC Concept

This section addresses itself to the several aspects of the proposed System Effectiveness Analysis and Control concept. These include system/cost effectiveness (S/CE) in general, measures of effectiveness (MEs), some thoughts on the S/CE analysis and control pertaining to the proposed SEAC, and the involvement required from upper echelons.

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I am not inventing new techniques in system and cost effectiveness analysis; I only propose its application in a given manner and a given area. An actual implementation will require prior preparation of analytical, organizational, and administrative plans and procedures.

System/Cost Effectiveness

System effectiveness, simply stated, is a quantitative measure of the extent to which a system may be expected to achieve a set of mission tasks within a specified environment. Cost effectiveness, simply stated, is the figure of merit that relates the value expected or received to the resources required or expended. The technology of S/CE embodies both scientific and engineering concepts and techniques. It can be used to facilitate the creation and selection of system designs that optimally balance technical, schedule, and cost to meet operational needs within bounded resources.

This paper does not presume to invent new wheels in effectiveness analysis. Modern operations analysis techniques have long existed and been applied to support major decisions in the military and other sectors of our society. Within today's defense community, however, the applications of these techniques seem to miss the significant system level where, for a while, during the Robert McNamara tenure at DOD, it was on the ascendancy. At the system acquisition organizations in the government and at the contractors, various technical support groups address themselves to analyses of discrete parts of system effectiveness, such as the widely ranging aspects of reliability, performance, cost, vulnerability, etc. They do not, however, direct themselves in a unified, timely manner that may be characterized as a systematic process in system/cost effectiveness. It is my intent to bring the latter into being as an institutionalized activity to be highly exploited during the system acquisition cycle.

The critical elements of an effective use of system/cost effectiveness analysis technology include: (1) measures of effectiveness or figures of merit (FOMs) as criteria of effectiveness, and (2) models or frameworks for effectiveness evaluation and prediction. Each of these is a highly challenging subject that merits individual lengthy discussions. They involve areas in our de-

Aircraft Fleet	FH/MO/A/C	Readiness	Flight Reliability	Log Support Costs per FH	Unavailability hrs per FH due to Maint & Supply
C-5A	57	.464	.986	$1488	6.7
C-130A	33	.523	.984	435	10.1
C-130B	40	.609	.985	391	5.4
C-130E	51	.581	.993	437	5.8
C-141A	90	.510	.995	435	3.8
KC-135A	28	.667	.995	443	8.3
F-15A	19	.570	.996	953	15.0
F-15C	21	.714	.995	855	9.3
F-16A	24	.681	.996	866	12.6
F-16B	18	.587	.992	934	16.3
A-10A	30	.712	.995	327	6.6
A-7D	20	.614	.994	432	13.6
F-4C	14	.471	.993	866	26.1
F-4D	17	.544	.993	924	18.6
F-4E	12	.534	.995	1500	19.2
RF-4C	20	.564	.990	759	15.4
F-111A	17	.430	.982	1275	23.6
F-111D	18	.403	.990	2401	22.9
F-111E	19	.612	.986	1205	14.3
F-111F	18	.509	.987	1699	20.2
FB-111	24	.464	.985	1634	16.2
B-52D	34	.510	.994	1148	10.6
B-52G	32	.435	.992	1238	12.8
B-52H	34	.478	.996	1198	11.1
E-3A	90	.642	.987	311	2.7

- **Data Base: 25 USAF Fleets (5504 Aircraft)**
- **Time Frame: First 3 Quarters of 1981**
- **Some Effectiveness Parameters**

	AVERAGE	RANGE
■ Utilization	28 FH/AC/MO (222)	12.4 - 90.2 (132 - 304)
■ Reliability		
● Before Flight	0.975	0.918 - 0.996
● In Flight	0.991	0.982 - 0.996
■ Maintainability	13.09 MMH/FH	2.73 - 26.14
■ Alert Availability	0.553 (0.973)	0.403 - 0.714 (0.961 - 0.9847)
■ Logistic Support Costs	$709/FH	$311 - $2401

( ) For reference only. Data on 4 fleets of Boeing commercial airplanes, 1978-1981.

fense acquisition process that have been grossly neglected. This neglect is responsible for confusion at all levels in the aerospace community and beyond as to what constitutes success, relative or absolute, in any sense of total system effectiveness or in its broad components of readiness, capability, and affordability.

System and force effectiveness parameters are, by their nature, all-powerful yardsticks for characterizing the relative strength or weakness of any part of a defense force. They can be readily structured in terms easily understood by the general public and eagerly disseminated by the media. To the extent that official and objective standards for such effectiveness characterizations do not exist, we will continue to see their use and misuse as suits the special interests of some general, admiral, departmental secretary, or even a president. These individuals will, of course, always have the readily bought corroboration of profit-motivated or "not-for-profit" technical consultants. The absence of established criteria for system/cost effectiveness thus hurts the national interest in two significant ways: We don't have their constructive benefits in better planning and controlling for more defense capability and affordability, and we don't have the protection from their destructive or confusing apples-vs.-oranges use for political gain.

A common or standard language is sorely missing. The existing situation represents a diverse use of measures of effectiveness and corresponding definitions when available. It defies the need for commonly accepted methods by which to characterize an acquisition product's planning factors, its program's achievements, or the responsible person's candidacy for commendation or condemnation. Some may consider this condition to be purposeful and incorrectible. In spite of my own observations that tend to support that position, I choose to be an optimist.

One of the hopeful signs of progress in this area is the advent at the Air Force Logistics Command of the K051 reporting system. It periodically reports on some of the effectiveness and support cost parameters for many fielded major USAF weapon systems, based on existing field data gathering methods. For the developing system, a number of efforts many years ago were

Affordability. Bounded cost effectiveness. The limit dollar value within which the mission related capability must be provided at a designated level of effectiveness on a life-cylce basis.

Cost Effectiveness. Life-cycle cost per unit of system effectiveness.

System Effectiveness. The statistical product of availability times dependability times capability.

Availability (or operational readiness). The probability that the system will be operable and ready to initiate a mission at a random point in time. Influencing factors include manning, operations, maintenance, logistic support, repair time, logistics time, administration time, reliability characteristics, base survivability.

Dependability. A measure of the system's operability condition during the conduct of the mission. Influencing factors include reliability and in-mission repairability.

Capability. A measure of the system's ability to achieve specified mission objectives or results. Influencing factors include offensive and defensive functional performance parameters, enemy threats, vulnerability, and human performance.

Life-Cycle Cost. Costs of acquisition plus costs of ownership plus costs of disposal.

Costs of Acquisition. Costs of RDT&E plus costs of end item procurement plus costs of initial investments for product support.

Costs of Ownership. Costs of operations and maintenance plus costs of logistic support for the end item and its supporting systems; to be applied over a given number of years of operational life.

directed toward evolving analytical formalisms in system and cost effectiveness; e.g., extensive studies by the Weapon System Effectiveness Industry Advisory Committee (WSEIAC) and Rome Air Development Center. But only the area of life-cycle cost continued with little interruption toward the development of models and their use for top-level decisions in at least some procurements. The ball in the broader system effectiveness technology was dropped. What is needed now is a renewed effort toward some standardization at the DOD level in measures of effectiveness and in analytical models covering each major contributing component of S/CE and each major mission area. Simultaneously, a concerted effort should be made to reconcile the various differences found among official reports on effectiveness parameters for existing fielded systems, and to adopt the modifications to field reporting systems needed to halt the perpetuations of useless, confusing, or outdated routines.

Figure 1 is a simple reference for the definitions and relationships of the system effectiveness terms used here. They are not intended to force conformity or to imply a unique solution to the stated modeling problem. But the problem must be confronted and solved in common for the total defense community, since it relates to the efficient and effective provisioning for our national defense without regard for the organizational boundaries of our military services.

Measures of Effectiveness

System-level technical and affordability measures of effectiveness are critically needed for the logical initiation and conduct of a system's acquisition program. They are indispensable to systematic, justifiable, and disciplined planning and structuring of the program in terms of technical and budgetary needs in order to ease its timely start. They are also vital for the program's performance monitoring and control in order to enhance its efficiency and optimize its military product's effectiveness. The failure to properly institutionalize such measures of effectiveness at the system-management level represents a neglected area in system acquisition. This has served

to degrade the efficiency and effectiveness of that otherwise highly structured process. A great interdependence exists among technical, cost, and schedule factors in the evolution of a complex military system. Failures in planning or control of any of these has too often resulted in interrelated deficiencies of non-readiness, overruns in costs and schedules, and years of supportability nightmares.

I propose that a series of system-level measures of effectiveness be used in program planning and control of every mission critical system. It would include several top-level or primary MEs carried in top-level system documentation, and a number of derivative and tightly interrelated secondary MEs to be used for design and control of lower-tier system components.

The top-level or primary MEs for a system would include at least one that is critically mission-related, and a corresponding one that specifies the limit cost for a unit of that mission effectiveness. These top-level MEs would be established by the appropriate military department primarily on the basis of top-echelon strategic planning, such as that provided by DOD's Consolidated *Guidance Document* and the associated constraints of the Total Obligational Authority set for each component of the Department of Defense. Since DOD's Joint Strategic Planning System provides systematic considerations of alternate methods to meet national security objectives and corresponding needed force levels, the cited outputs of such a system represent the most logical source for system/cost effectiveness measures of control.

The primary MEs would in turn be analyzed, within the context of mission and force elements and major system components, into allocated lower-tier MEs. These would be program requirements usable for design and cost trade-offs and decisions during concept formulation (or subsequent variations thereof), as well as for control criteria during full-scale design and production. This type of buildup and relationship among mission and program elements would always retain the logical thread to the top-level guidelines for the system, and would minimize past weakening effects upon it from human frailties in program estimating and control.

System/Cost Effectiveness Analysis

A basic element of the SEAC concept is the establishment of a system/cost effectiveness analysis deputate or directorate at the parent organizations for system acquisition program offices. Such an entity would satisfy a number of current and projected system analysis needs in the system acquisition community that cannot be met adequately with existing organizational structures. The proposed new organization would combine scattered and diverse analytical services operating disjointedly on bits and pieces of the system/cost effectiveness entity. The result would be a unified functional group having a clear, logical, and critical role at a high level in the system acquisition process. It must be independent of the engineering or test chain of command for obvious reasons of conflict of interest. The new organization is envisioned to play an operations analysis role in all effectiveness parameters discussed above. It will not obviate the proper engineering role in reliability, for example; rather, it will permit the latter discipline to better focus on the area of design reliability. Similarly, the logistician's proper role in availability is retained, as is program control's responsibility in cost reporting and tracking.

The new group would be chartered to provide services to include: (1) the full range of analytical support in system/cost effectiveness for the system program office upon request of the Deputy Program Manager for System/Cost Effectiveness (DPMSE) as identified in the discussion on S/CE control below; (2) serving as an official source for unified, consistent, and (eventually) standardized information in system effectiveness for all disciplines contributing to technology or system program activities; (3) promoting standardization in system effectiveness models and in measures of effectiveness for the major mission types and sectors thereof; (4) maintaining a library for systems/equipments effectiveness experience; and (5) serving as an impetus for adopting improved data collection and reporting methods for fielded systems in order to enable a correlation between standardized effectiveness figures of merit for developing systems and similar figures of merit for existing systems.

The analytical services to be performed by the new organization for system/cost effectiveness include the following involved parameters:

1. Availability/Sustainability and Dependability Analysis
   - a. Reliability
     - (1) before mission
     - (2) during mission
   - b. Maintainability
2. Capability Analysis
   - a. Probability of mission functions success
     - (1) by mission
     - (2) by mission sector
   - b. Vulnerability/Survivability
     - (1) by mission
     - (2) by mission sector
3. Life-Cycle Cost Analysis

System/Cost Effectiveness Control

If the system/cost effectiveness analysis support organization performs its charted service on behalf of the system program office during the concept formulation phase, a credible and justifiable set of measures of system and cost effectiveness will have been formulated and blessed at all echelons as formal program control parameters. These would be incorporated within system specifications and contract documentations to serve as high-level controls for program management at the customer's program office and that of the contractor. In each case, a deputy program manager for system/cost effectiveness would be established within the program office organization, modified to operate under the System Effectiveness Analysis and Control concept. This deputy to the program manager would be responsible for the following:

1. Obtaining from the supporting System/Cost Effectiveness Analysis Deputate or Directorate:
   - a. Evaluations of the specified top-level MEs in terms of major system and program bounds as seen from the responsible acquisition organization.
   - b. Allocated or secondary MEs with supporting trade analyses needed as major requirements in high-level specifications for the system. These would cover the system-critical constituent parameters at appropriate levels of the system's work breakdown structure (WBS).
   - c. Periodic evaluations of designs during the program's progress to ascertain any expected deviations from established MEs.
   - d. Analysis and evaluation, as needed, of proposed or mandated

changes in the system or program. This will include trade analyses required for program management decisions.

2. Obtaining coordination upon established or changing MEs in his program from concerned operational, logistics, engineering, and program control executives.

3. Actively tracking the performance of program management in meeting S/CE MEs or FOMs.

4. Providing critical support to the program manager for high-level reviews at significant milestones.

5. Advising the program manager to take corrective actions as needed to avoid ME shortfalls.

6. Managing evaluations of impacts upon system MEs due to program changes for technical, cost, or schedule reasons.

The delegated role of the DPMSE will be, in effect, one of a "czar" over the establishment of allocated MEs within a system program, monitoring program progress for detection of potential shortfalls in MEs, and recommending corrective actions where needed. His advent to the system program office need not diminish the indispensable role of the deputy program manager for logistics (DPML), the chief engineer, and the chief of program control. Rather, it strengthens their effectiveness by more clearly separating them from a responsibility for the overall system effectiveness for which they were not well conceived and organized. The DPMSE would be staffed primarily with some operations analysis personnel on collocated assignment from the system/cost effectiveness analysis organization. The DPMSE staff will include senior specialists in three functional areas of analysis: operational readiness and sustainability, capability (including survivability), and affordability. The bulk of the analysis activity to support the massive demands during concept formulation and for subsequent periodic surveillance milestones will be conducted at the home analysis group.

Existing performance measurement methods employed by program control for a program's progress in schedule and cost have become highly structured and well-disciplined. An excellent feedback has been developed between the budgeting process programmed funding and the reporting of progress against it by elaborate formalizations in being. They include cost/schedule control system criteria, cost performance reporting, cost/schedule status reporting, and in-house Selected Acquisition Reports, which go to top-level DOD management and Congress. The weakness in this performance measurement and reporting system is the insufficient realism of the plans that the reporting and controls are trying to make good. A more realistic planning would be enforced by a better definition of the program's technical elements through the system of MEs, based at the outset on a compatible and enforceable interrelationship among performance, cost, and schedule. Stated another way, a system program that is technically well-structured in mission-related and force effectiveness terms will also enhance the corresponding cost and schedule planning, as well as the efficiency of subsequent management controls through the already well-established techniques.

Upper Echelon Involvement

The concept of System Effectiveness Analysis and Control for greater success in acquisition programs cannot be effectively implemented unless there is an appreciation for its benefits and an involvement *in its institutionalization* by the upper echelons of defense acquisition control. Operational commands must appreciate the fact that analytically sound requirements for system readiness and capability at a program's inception, as well as subsequent tight management control aimed to ensure a quality end product, will serve to enhance the effectiveness of their operating forces. Logistics powers-that-be should appreciate the fact that a system support base that has been optimized for cost effectiveness is greatly to be desired, since support costs and military impedimenta will have been diminished in the process. The budgeting community should be pleased that a program to be funded will have been exercised analytically to the point that it can be shown as a smart investment in a supplement to the nation's defense. Finally, the development and acquisition commands should welcome greater cooperation from all sectors of the defense community in being more efficient in its role of defense product acquisition manager.

The systematic tracking and control of S/CE parameters cannot be reasonably institutionalized as part of the acquisition process by the slow upflow of routines from the bottom up. It must take the more rapid top-down directive route. A detailed formalization plan must be structured and properly blessed. As mentioned in the discussion of measures of effectiveness, each service department must be responsible for establishing the top-level MEs for its system programs based, on the Consolidated Guidance Document and the Total Obligational Authority constraints approved by the Secretary of Defense. Top-level staffs in Congress and the administration must incorporate the S/CE measures of effectiveness as a major criterion for tracking and judging a program's merit and progress, along with schedule and absolute costs. All applicable program management reviews (e.g., SAR, SPR, PAR, CAR, FAR) designed to provide program status visibility, problem identification, and decision alternatives must report upon progress in relation to the same high-level measures of effectiveness justified as having defense force merit at the time of the program's approval.

By adopting these MEs at the highest echelons, these critical parameters will also be accorded their deserved respect and treatment at all other levels of acquisition management. Appropriate formalizations through regulations and directives will naturally follow.

Summary

Dissatisfaction with the efficiency of our defense acquisition programs has been widely documented. This paper concurs in the reality and gravity of the problem. An approach to its relief is offered that is not incompatible with most of the initiatives in defense acquisition improvement. A grass roots supplement to the "Carlucci Initiatives" is here proposed—now to find a "Carlucci" to accept and insititutionalize it.

Note

1. The logistics support cost (LSC) referred to here is the sum of the LSCs for all inclusive work unit codes (WUC) and any TCTO man-hour costs; work unit codes logistics support cost is the sum of inclusive Federal Stock Number (FSN) LSCs plus on-equipment manhour costs; Federal Stock Number logistics support cost is [24.21 times field MMH] plus [packaging and transportation] plus [condemnation replacement] plus [depot repair]. Further details on this definition are available, but not considered important here.

Brainsidedness

What We Do Know Can Help Us

DSMC's experience with student work groups indicates that awareness of left-brain, right-brain thought processes can substantially improve a group's ability to work together effectively.

Lieutenant Colonel George Ellis, USAF

A program manager has just learned from higher authority that considerable additional testing will be required during the development of his new system. At the same time, however, the scheduled milestones must be met. The manager formulates an *ad hoc* team of his brightest people and schedules a problem-solving session to address the issue. After explaining the purpose of the session, he suggests a step-by-step problem-solving process:

—Identify the problem
—Gather data
—List possible solutions
—Evaluate solutions
—Select best solution
—Apply the solution

But when the manager tries to get the group to follow this process, he runs into trouble; some members will not stay in sequence. They skip steps, work backward, mix steps together. The manager and some of the other members become very frustrated with the lack of orderly progress.

Task oriented, the program manager admonishes the group to follow the

process more methodically. Many of the "put-down" members experience frustration and reduced motivation.

Contrast this situation with a scene from an advanced management training program at a defense college outside of Washington, D.C. A team of students has been tasked to solve a difficult management problem within the next 2 hours. The participation by individual members reflects differences in approach, which resemble the *ad hoc* team described above. Some members are logical and controlled as they discuss the problem. Other members seem to contribute in a much less scientific and predictable way. However, the similarities between the two groups cease here.

As opposed to the group struggling unsuccessfully in the program office, the group of students is not bothered by the differences among their individual approaches. In fact, there is a give-and-take that seems complementary. The climate within the group is very open at the outset, and the inputs of each member (although often quite different from those of the other members) are accepted as relevant. After this period of free-wheeling interchange, one of the members suggests they try to reach a consensus on the definition of the problem. The discussion follows a logical course as the "effects" of the problem are gathered, evaluated, and accepted by the group. The climate returns to a more open, uncontrolled state as the group searches for "causes" of the agreed-upon effects. A brainstorming technique is used to generate a lengthy list of possible causes. When one member suggests that some of the possible causes listed might really be "effects," the group is comfortable in accepting the suggestion and able to return to a formerly "closed area of business."

The progress of the student group continues in an "ebb-and-flow" pattern of control and openness, of logic and new ideas. Some members contribute more heavily in one phase than another, and their individual differences are quite acceptable to the group.

□ This is a revised and retitled version of the article published in *Exchange: The Organization Behavior Teaching Journal*, Volume 8, Issue 4, 1982.

■ *Lieutenant Colonel Ellis is an instructor in DSMC's Policy and Organization Management Department.* ■

At the bottom-line point in this scene, the students report to their professor and present an analysis and solution that delights him because of its high quality.

Individual Differences and Group Effectiveness

Educators have long known that individual differences tend to interfere with the cooperative effort so vital to high performance in organizations. In his extensive research on the nature of high-performing systems, Dr. Peter Vaill of George Washington University has frequently returned to the issue of individual differences. One possible explanation is that our human frailties get in the way of our effectiveness as we tend to be uncomfortable with those who are different from us. Frequently, we fail to recognize that individual differences can be complementary and lead to a better result. In the field of organizational behavior, the concept of synergy is used to describe the phenomenon of the parts of a whole working effectively together in an interdependent (mutually supportive) rather than independent manner. Synergy is said to be achieved when the whole is greater than the sum of the individual parts. Vaill describes this concept as "joint optimization." One means of helping to achieve synergy and high performance in organizations would be to reduce the "interference" connected with individual differences.

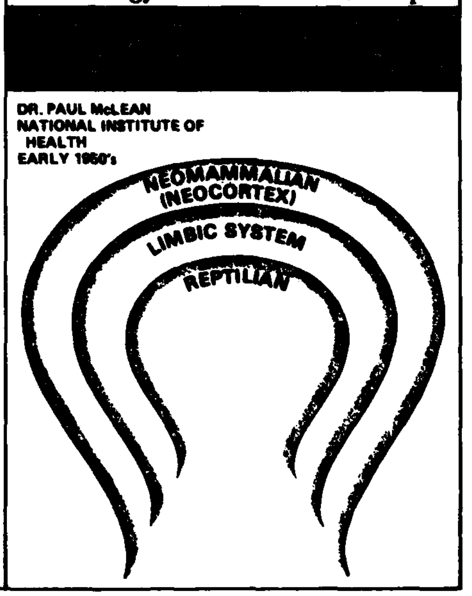
At the Defense Systems Management College, Fort Belvoir, Va., we have initiated a program to help managers from the Department of Defense and defense industries learn more about the nature of individual differences and the way those differences can be negotiated and used effectively. Teambuilding, using the concepts of behavioral science, has been an area of emphasis in our course for program managers for several years. Classes of approximately 200 students with management experience ranging from 5 to 15 years are divided into six-person work/study groups. The case-study method is used and the students are challenged as groups to solve the problems embedded in the cases. Thus, team effectiveness and high performance becomes an important objective to the highly competitive students, who tend to be high achievers and ambitious for career progression. On the premise that organization dysfunction and loss of energy are often caused by the failure to understand and effectively use individual differences, we have begun to explore a new form of teambuilding, and we are encouraged with the initial results.

Brain-Dominance Differences

The basic ingredients of our program are self-awareness, awareness of individual differences, and experiential learning around those differences. One principal area of awareness addresses individual differences concerning brain dominance.

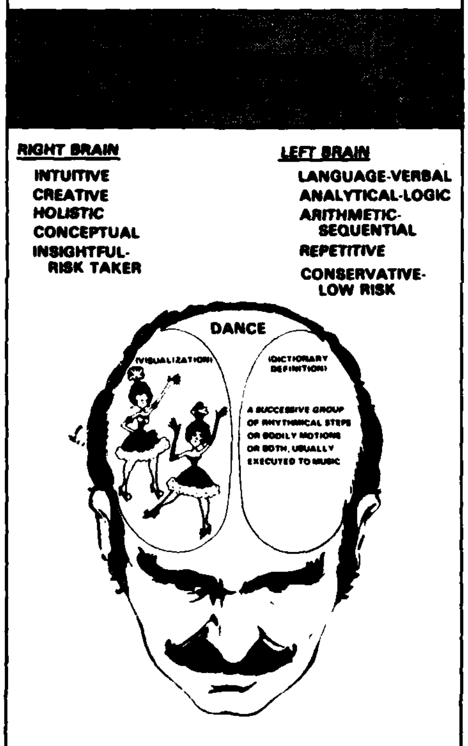
From the research conducted during the past 30 years, we have learned much about the human brain to account for individual differences. The concept of the triune brain (Figure 1) developed by Dr. Paul McLean helps us to understand the evolutionary development of the human brain. From McLean's work we have learned the significance of the limbic portion of the brain, which controls our emotions, and interpersonal functions. Moreover, we know that our most advanced capabilities, such as verbal and abstract thinking capacities, are enabled by the neo-cortex (cerebral) portion of the brain.

Dr. Roger Sperry's experiments with brain-damaged and epileptic patients revealed that the human brain is structured into two separate hemispheres (left and right) connected by a switchboard mechanism referred to as the corpus callosum, through which electrical impulses pass from one side of the brain to the other. In the case of epileptic patients, the exchanges of electrical energy are so massive that the pa-



tient becomes "overloaded" and reacts with an epileptic seizure. Sperry found that epilepsy could be relieved by surgically severing the corpus callosum, thus reducing the transfer of electrical energy. In some cases, it was necessary to sever the connection completely. In the experiments connected with this work, Sperry found that the two sides of the brain function in profoundly different ways.

The left side performs the rational, logical, sequential, arithmetic, linear, routinized functions. Further, the left side is the seat of our verbal capabili ties and operates very conservatively to avert risk. Conversely, the right side is intuitive, spatial, holistic, creative, can build patterns from a few sketch details, and takes risks easily. Our capacity to visualize and fantasize resides on the right side of our brain, and the right side characteristically searches for meanings (Figure 2).



The work of Dr. Robert Ornstein has provided further support to the idea that distinctly different modes of thought are conducted in the brain's right and left hemispheres. Moreover, Ornstein has studied the cultural differences concerning individual tendencies to use one side more than the other. In the western culture, we have been on a decidedly rational bent, at least since the ascendency of cause-and-effect reasoning in Aristotle's Greece.

The Culture Connection

In a mutually supportive manner, science and technology have developed, and our societal values have evolved to the point that the emphasis in our educational system is weighted heavily toward the left-hemisphere functions of reading, writing, arithmetic, science, and scientific applications. In a sense, our highly developed, high-technology culture stands as a monument to the development of our left-hemisphere capabilities. Some thoughtful academics, notably Paul Feyerabend, William Barrett, Thomas Kuhn, Charles Lindblom, James L. Adams, and Russell Ackoff, have pointed to the dangers of overemphasizing the rational approach.

In contrast, the Eastern culture has continued to value and emphasize the functions of the right hemisphere, as evidenced by the holistic philosophies and visual and artistic orientation of life. However, while right-hemisphere functioning has flourished, in many parts of the East these societies have not been able to organize sufficiently to feed and clothe themselves. As Ornstein suggests, a blending of the approaches of both cultures may be in our long-run interests. At this point an interesting question *arises concerning the Japanese:* Has their ability to effect this blending been a key to their recent success?

As we focus on the major issues of energy, stagflation, unemployment, and the ecological balance, we can see to an increasing extent the increased complexity and interrelatedness of our organizations, their environments, and the issues themselves. An overdependence on the left mode of thought may not be an effective approach, given this complexity. It may be in our best interests to take greater advantage of the capabilities of the right brain.

For effective problem-solving and decision-making, both sides of the brain are vital and complementary. An unchecked bias on the left side can lead to overlooking context and premature bounding and closure of problems. The right side can compensate through its capacity for flexibility, risk taking, dealing with complexity, and attention to context and patterns. On the other hand, the rich intuitive content of the right brain needs the rational capabilities of the left side to articulate and translate that content into action.

Using Brain-Dominance Differences in Teambuilding

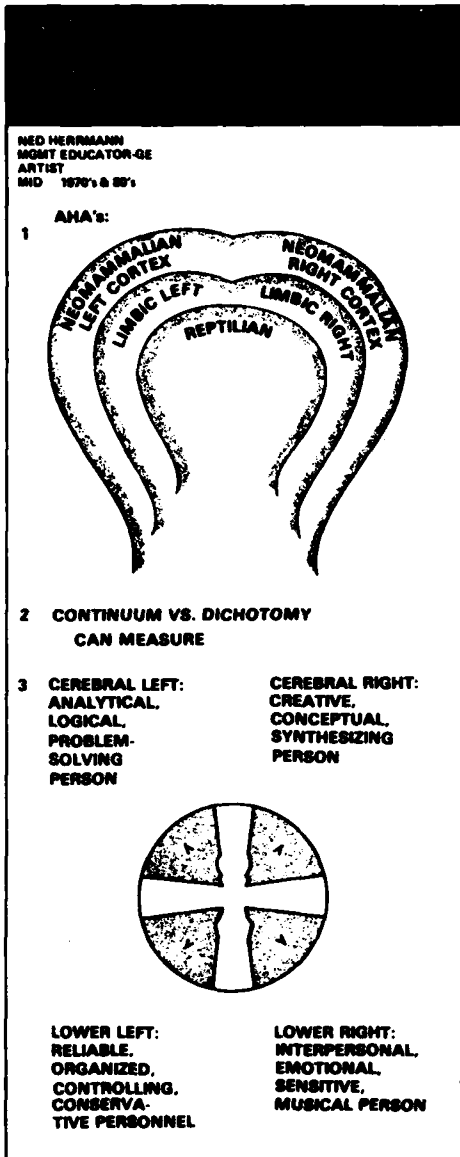
Where, then, do these research findings and scholarly suggestions lead us? On an individual level, perhaps we need to become more aware of how we use the two sides of the brain and to increase the functioning of a neglected side, if we find one. Given increased awareness of individual tendencies and preferences for using one side of the brain vs. the other, we may become better able to formulate and manage learning and work groups. At the organization level, we might seek to improve human resource management. Awareness is the key to unlocking these potential benefits.

The work of Ned Herrmann, Manager of Management Education for General Electric, located at GE's Management Development Institute at Crotonville, has provided an important step toward increased awareness of individual brain dominance. Combining the findings of McLean and Sperry, Herrmann has theorized that the limbic system of the brain, like the more advanced cerebral portion, is also divided into right and left hemispheres, which led him to a quadrant view of the brain and brain-dominance patterns (Figure 3). Influenced by the work of Ornstein, Henry Minztberg, and others, Herrmann has conducted research that began with General Electric managers and highly creative associates connected with his avocation as an artist. Encouraged by his early findings, Herrmann has expanded his research to subjects representative of the citizenry at large. To date, he has worked principally with Americans.

Herrmann's research has led to the design of a survey instrument that reveals an individual's brain-dominance pattern. Data is collected in the following areas:

—Biographical, educational, and occupational
—Handedness
—Best/worst school subjects
—Performance of tasks
—Self-descriptive adjectives
—Hobbies
—Energy level
—Motion sickness
—Extroversion/introversion

Tendencies and preferences become apparent along four dimensions: cerebral left and right and limbic left and right. Reflecting the bias toward the



left side of the Western culture, most individual members of business and government organizations show strong tendencies toward the left-side dimensions, both cerebral and limbic, indicating preferences for logical, analytic, mathematical, technical, controlled, conservative, planning, organizing, and administrative functions. However, individual differences abound in the organizations Herrmann has surveyed, with some members demonstrating more balanced double dominant tendencies and others a clear preference for right-brained functioning. Intrigued with the potential of Herrmann's instrument serving as a vehicle for increased self-awareness and teambuilding around individual differences, we initiated a brain-dominance project at the Defense Systems Management College.

In our effort to facilitate teambuilding for the class of approximately 200 student/managers, we followed a five-step process:

—Administer the Herrmann Brain Dominance Survey;
—Provide relevant background and concepts through lecture-discussion;
—Feed back results and implications of individual and group patterns;
—Facilitate teambuilding around results;
—Follow-up.

We provided only a brief introduction to the administration of the survey instrument. Our principal objective was to motivate the students by stressing the potential value of the survey as a vehicle for increased self-awareness. We suggested they respond as spontaneously and candidly as possible in order to provide a valid view of themselves. We intentionally withheld the rationale behind the survey and the implications of the patterns that might emerge.

After the survey was collected, we engaged in a lecture-discussion session that highlighted the background and research that had led to the development of the survey and the survey's potential applications for personal, educational, and organizational use. The high levels of student interest and enthusiasm led to lively discussions that overflowed into after-class sessions and follow-on classes.

After the surveys were scored, feedback sessions were held and each student was provided his individual brain-dominance profile, derived from the survey data, along with explanations of the implications and significance of the patterns. We followed the individual feedback with discussion of activities, exercises, and programs that could be considered by individuals who wished to alter their patterns—particularly to increase the functioning of the right brain.

To facilitate teambuilding, we then provided the students the opportunity to break out into their six-person work/study groups (the membership of which was fixed for the entire 20 weeks of the course) to discuss their individual brain-dominance patterns and the composite patterns they found in their groups. We suggested that they might wish to engage in a reality check (the extent to which individual patterns derived from the survey agreed with observations of other members) and to consider how the resources of the group could be best employed to provide a whole-brained approach to group problem solving. This was the initial step in a series of teambuilding sessions, planned and unplanned, that seemed to lead to increasingly greater levels of trust within the work/study groups.

Once again, the discussions were exceptionally lively with openness and sharing of perceptions, views, and feelings increasing exponentially as the discussions continued. The excitement and enthusiasm surrounding the teambuilding sessions was similar to that experienced in previous classes using the Myers-Briggs Type Indicator results as the basis for work group discussion, and was considerably greater than our experience using the Johari Window survey as the discussion vehicle. We followed-up the initial teambuilding sessions with periodic sessions with the entire class, with separate work groups, and with individual students. Our purpose was to help clarify the experiential learning that was occurring through the work group problem-solving exercises, their reflections on the implications and effects of brain dominance, and the relevant communication that was occurring among the students on a continuous basis.

Four students were sufficiently stimulated to voluntarily engage in research in brain dominance over and above an already demanding curriculum and work load. Working in pairs, they investigated (1) *Brain Dominance and Group Performance* and (2) *Correlations Among Results of the Herrmann Brain Dominance Survey, the Myers-Briggs Type Indicator, and the Kolb Learning Style Survey*. Results of those studies are available separately.

Findings

As mentioned earlier, we found high levels of student interest and enthusiasm resulting from the application of the Herrmann Brain Dominance Survey. The students, on a continuous basis, made special efforts to seek out faculty members in and out of class to discuss their learnings and pose questions. The power of self-awareness was overwhelmingly evident. Many 40-year-old managers behaved as though a light had just been turned on in terms of explaining themselves to themselves. They were excited by the new insights

and asked for their wives and children to be included in the surveys. The excitement of self-awareness extended to being able to account for differences between self and others. There was great enthusiasm within the work groups concerning the new-found capacity to discuss perceived differences in behavior among the team members in the language of brain dominance. Trust levels were elevated. Other evidence of positive student response was apparent in the large numbers of cartoons and articles dealing with brain dominance that students would clip, circulate, and post on bulletin boards. Moreover, formal and informal critiques provided to the College administration commended the brain-dominance teambuilding program.

From the faculty point of view, we saw a decided upswing in student performance compared to previous classes. Much greater cohesion in the work/study groups was observed as students organized, communicated, socialized, and exhibited pride in their identities as groups to a far greater degree than seen at the College previously. A good example exists in the consensus-seeking exercise, *NASA On the Moon*, used for each class. A principal objective of the exercise is to learn more about achieving group synergy through seeking consensus. For this exercise, we measure the degree of synergy achieved by the improvement of the group score over the average of the individual scores and also by the extent to which the group score is better than the best single individual score. The synergy achievement for the class that teambuilt around brain-dominance differences was considerably higher than previous classes.

Another example of improved team performance was observed in the series of case studies used to integrate the curriculum. The faculty found substantially improved teamwork and problem-solving effectiveness during those case-study exercises compared to past classes. While many other behavioral examples could be cited that suggest improved teamwork, I must mention one other signal we received from our "brain-dominance" class—increased creativity.

Without precedent and without faculty encouragement, the students produced a chronicle of key events occurring during the course. Cleverly conceived and professionally produced, the chronicle stands in testimony to "whole-brained" achievement. Creative, right-brained humor was articulately translated into action—a left-brain function.

Conclusions

Our experience conducting teambuilding around the notion of brain-dominance differences suggests that powerful benefits may be gained. It appears that feedback to individuals on their brain-dominance patterns has some of the unfreezing effects that Lewin has said must precede change. Moreover, the sharing of individual patterns by members of assigned groups seems to improve levels of trust and reduce individual defenses, thus increasing the likelihood of greater group cohesion and high performance.

While we did not conduct a controlled experiment, we are encouraged and plan to continue the brain-dominance teambuilding with subsequent classes and to seek opportunities for application in the field of defense acquisition. Our experience has produced the kind of high-performance results that all managers would like to have. We hope that our work so far will encourage other exploratory projects.

Second Sourcing to Enhance Competition

(continued from page 21)

These problems can be either eliminated or minimized, however, by proper advance planning, early and forthright communication with the contractors, and effective implementation of an appropriate second-sourcing method.

Recommendation

The recent changes to DODD 5000.1 and DODI 5000.2, as discussed earlier, should cause acquisition managers to give serious thought to including production competition in their acquisition stategies. However, to help program managers make effective decisions regarding competition, additional guidance should be provided in a separate instruction or by publication of a desk guide or handbook on the complex subject of second sourcing and production competition. Such an instruction or desk guide should include the potential benefits and problems associated with production competition, the various methods of generating a second production source, and a model or methodology for deciding whether or not to seek production competition and, if so, which of the various methods is best suited for a particular acquisition program. In addition, the handbook should provide information on the mechanics of generating a second source and utilizing the competitive environment once it is established.

This paper, particularly the Second-Sourcing Method Selection Model, is offered as the foundation (for discussion purposes at least) of such an instruction or desk guide.

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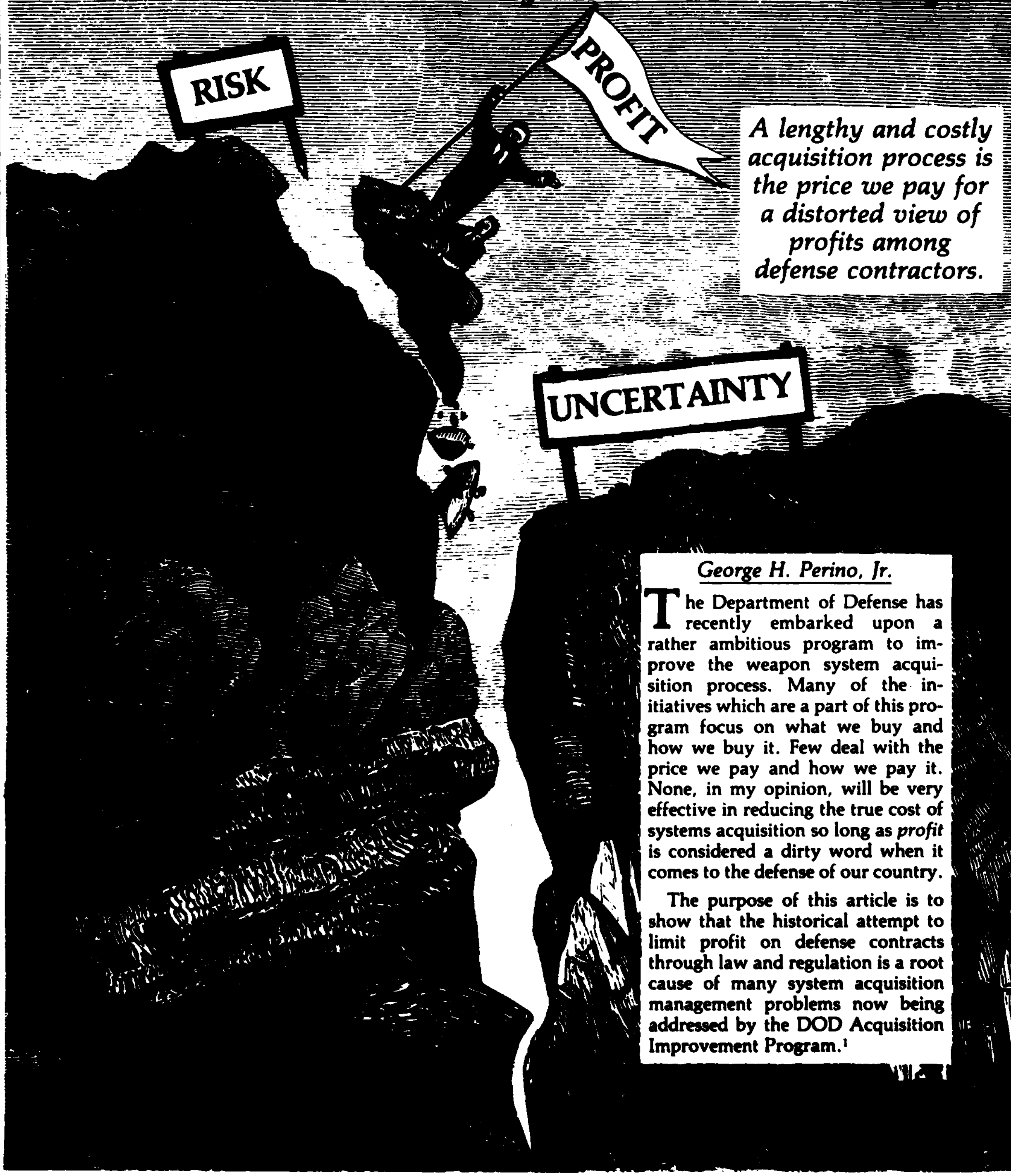
WHAT PRICE DEFENSE?

Profit and Profitability in Defense Industry



A lengthy and costly acquisition process is the price we pay for a distorted view of profits among defense contractors.

George H. Perino, Jr.

The Department of Defense has recently embarked upon a rather ambitious program to improve the weapon system acquisition process. Many of the initiatives which are a part of this program focus on what we buy and how we buy it. Few deal with the price we pay and how we pay it. None, in my opinion, will be very effective in reducing the true cost of systems acquisition so long as *profit* is considered a dirty word when it comes to the defense of our country.

The purpose of this article is to show that the historical attempt to limit profit on defense contracts through law and regulation is a root cause of many system acquisition management problems now being addressed by the DOD Acquisition Improvement Program.[1]

Some might argue that we no longer suffer from the post-World War I "merchants of death" syndrome that underlay such "excess" profit-limiting efforts as the Vinson-Trammell Act of 1934 and the Renegotiation Acts of 1942, 1948, and 1951. I would contend that far too many people still believe that defense contractors make excessive profit on work they do for the government. I would also contend that, paradoxically, the price of defense will remain unacceptably high unless and until we increase the amount of profit industry can earn on defense business.

The central thrust of this article is simply stated: Unduly limiting contract profit leads to reduced levels of investment by the defense industry and increased participation by the government as a banker to the defense industrial base. It also leads to a highly complex and lengthy acquisition process, which increases the immediate cost of individual weapon systems and the ultimate price of national safety. While the DOD Acquisition Improvement Program is a positive step toward reversing this trend, it will only achieve limited success so long as those charged with implementation continue to attack symptoms rather than the illness itself.

If we are to understand the linkage between cause and effect, we must first understand the difference between profit and profitability. In oversimplified terms, profit is the reward for taking risks in business. Profitability is the ratio of profit to some basis for comparison; for example, the ratio of profit to total investment or the ratio of profit to equity investment. I believe that if a defense contractor is forced to accept artificially low contract profits, he will react by striving to increase profitability. This translates into low levels of equity investment accompanied by low levels of asset investment, which—eventually and inevitably—result in reduced productivity and increased systems acquisition cost.

The remainder of this article is devoted to the development of this argument with the assistance of what I will call, with tongue in cheek, the "Magic Formula." The formula is neither magic, nor is it new. It does, however, provide us with a simplified model of a business venture based on the not too widely understood proposition that:

Profit Margin × Asset Turnover × Financial Leverage = Return on Equity

Inherent in the model is a second, and more obvious, proposition that investment minus financing equals equity. The relationships captured in the Magic Formula were first introduced by the DuPont Company as measures of corporate performance a half century ago. They are well known to serious students of business. Their use to explain the sickness apparent in the defense industrial base and the frustration inherent in the system acquisition process is the thrust of what follows.

Profit vs. Profitability

Webster's dictionary lists one definition of "profit" as the compensation accruing to entrepreneurs for the assumption of risk in a business enterprise. More simply, profit is the reward that attracts investment of time, money, and talent. Profit, for our purposes here, will be defined as earnings after taxes, or *net income* (NI). Profitability, on the other hand, is the measurement of profit relative to some base. There are several classical measures of profitability used to compare the rewards of one business venture against another. Two are contained in the Magic Formula as it is stated above:

—*Profit margin* is profit relative to the sales that generated that profit and is often expressed as net income divided by *sales* (NI ÷ S). Profit margin is affected by the price received for goods or services and the cost of those goods or services. The greater the spread between price and cost, the greater the profit and the greater the profitability. Anticipated profit on sales (profit margin) is one of the key factors that attract business to particular products or contracts.

—*Return on equity* is profit relative to the stake the owners have in the business. Return on equity is typically defined as net income divided by *stockholder's equity* (NI ÷ SE). The more profit a business can earn, the more profitable it is for the owners. Thus, the anticipated profit relative to the capital at risk (return on equity) attracts entrepreneurs to particular firms or industries.

A third classical measure of profitability is *return on investment*—profit relative to the firm's investment in assets. Assets include such things as the buildings, machinery, and material needed to manufacture products for sale to consumers. The more profit earned relative to an asset's cost, the more profitable the firm's investment. Return on investment is a critical factor in allocating funds available within a business firm to particular product lines or markets. Return on investment can be expressed as net income divided by *total assets* (NI ÷ TA). I will expand the Magic Formula to include return on investment in a moment, but I must first say a few words about *asset turnover* and *financial leverage*.

Asset Turnover and Financial Leverage

Asset turnover refers to efficiency of asset utilization in generating sales. Asset turnover can be thought of as sales divided by the firm's investment in total assets (S ÷ TA). Asset turnover, then, would be the number of sales dollars generated for each dollar invested in assets. Increasing sales while holding the investment in assets constant would increase the asset turnover ratio. Holding sales constant while reducing the investment in assets would have the same effect. By combining profit margin and asset turnover algebraically, we see that they affect return on investment:

$$\frac{NI}{\cancel{S}} \times \frac{\cancel{S}}{TA} = \frac{NI}{TA}$$

Financial leverage refers to the use of borrowed money to finance the firm's investment in assets. It can be depicted by the ratio of total assets to stockholder's equity (TA ÷ SE). The more a firm can borrow, the more it can invest in assets for a given level of stockholder's equity. Return on investment and the use of financial leverage affect return on equity:

$$\frac{NI}{\cancel{TA}} \times \frac{\cancel{TA}}{SE} = \frac{NI}{SE}$$

By selectively combining asset turnover, financial leverage, and the three measures of profitability, we can

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modify the Magic Formula to distinguish between the results of corporate operations and the use of borrowed money to finance those operations. This will enable us to gain a better understanding of the interrelationship of profit, asset turnover, financial leverage, and profitability.

OPERATIONS

$$\text{Profit Margin} \times \text{Asset Turnover} = \text{Return on Investment}$$

FINANCING

$$\text{Return on Investment} \times \text{Financial Leverage} = \text{Return on Equity}$$

As one might imagine, there are numerous combinations of profit margin and asset turnover which, when combined, will result in identical returns on investment. In real life, however, we rarely find identical returns on investment when comparing one company or industry against another. Each has its own operating characteristics. Note the median returns on investment achieved in 1980 by major companies in the industries listed below.[2]

	Profit Margin	×	Asset Turnover	=	Return on Investment
Motor Vehicles and Parts	2.4%		1.48		3.5%
Office Equipment and Computers	7.3%		1.02		7.4%
Mining, Crude Oil Production	11.9%		.89		10.6%

Why the returns were different is not nearly as important as the fact that they were different. If those differences remained relatively constant over the long run, we should be able to conclude that the risk associated with manufacturing motor vehicles and parts must be significantly less than the risk associated with mining operations and crude oil production, since the reward in terms of return on investment is significantly lower.

If we were to conclude that the risk associated with operations was greater in mining and crude oil production, then it is also fair to expect that the owners of those businesses should reap larger rewards since they are the primary source of equity or risk capital to the industry. The second half of the Magic Formula, the part that deals with financing, shows us that return on equity was indeed higher for mining and crude oil production in 1980.[3]

	Return on Investment	×	Financial Leverage	=	Return on Equity
Motor Vehicles and Parts	3.5%		2.32		8.1%
Office Equipment and Computers	7.4%		2.04		15.1%
Mining, Crude Oil Production	10.6%		1.99		21.0%

Note also that, given our admittedly selective example, there appears to be an inverse relationship between asset turnover and profit margin, as well as an inverse relationship between financial leverage and return on investment. While these relationships may not hold true in the short run, they must hold true in the long run if you believe, as do I, that businessmen acting as individuals or in groups will do whatever is necessary to maintain a reasonable balance between risk and reward. Let us first take a look at business opportunities from the perspective of potential owners and lenders to see how efforts to achieve this balance affect investment and financing decisions.

Investment vs. Financing

It is important to recognize that the anticipated risks and rewards associated with any firm's investment in assets affect its ability to grow (or survive) through the infusion of debt and/or equity capital. An individual who has equity capital to invest will not put it into a particular business venture unless he believes he has the opportunity to earn a return sufficiently high enough to compensate him for the risks associated with that venture. Therefore, return on equity will affect a company's ability to raise fresh equity capital. High-risk, high-return business ventures attract the entrepreneur. High-risk, low-return alternatives do not.

Return on equity is a function of return on investment and the use of borrowed money to finance that investment. The amount of debt capital made available to a company is a function of the trend in return on investment and the risk associated with that trend as perceived by the financial community. An investment in assets that generates a relatively low rate of return subject to a relatively high degree of risk will not be tolerated for very long, and the firm's management will be forced to take steps to bring risk and reward into balance.

Furthermore, prudent lenders will demand that the company be able to obtain fresh equity capital should short-run misfortunes endanger its ability to repay principal when loans fall due. Thus, the risks and rewards of corporate operations must be in balance whether the firm finances its investment in assets with equity capital alone or with a combination of equity and debt.

Now, let's shift our focus from that of owners and lenders (the source of capital) to view business opportunities (the use of capital) from the perspective of the firm itself. Given that management understands the forces driving it to generate a satisfactory return with the funds it has available, it will tend to direct those funds toward business opportunities that promise a satisfactory return on investment. An investment that offers low returns relative to other opportunities will be attractive only if the risks are also relatively low. Return on a particular investment is a function of profit margin and asset turnover achievable on that investment. Here we find that the necessity to maintain a reasonable balance between risk and reward will establish acceptable limits on profit margin and the amount of time, money, and talent the firm's management is willing to put at risk. One would not expect prudent managers to invest a large share of limited resources in high-risk projects that do not also offer the opportunity for relatively large rewards.

Profit or Profitability

I contend that prudent businessmen will, over the long haul, take the necessary steps to balance risk and reward. If that balance cannot be achieved through an acceptable level of profit, it *will* be achieved through an acceptable level of profitability.

TABLE I

	Aerospace Industry					All Manufacturing Corporations				
	% NI/S	S/TA	% NI/TA	TA/SE	% NI/SE	% NI/S	S/TA	% NI/TA	TA/SE	% NI/SE
P1980	4.4	1.23	5.4	3.06	16.5	5.0	1.46	7.3	1.99	14.5
1979	5.0	1.26	6.3	2.92	18.4	5.7	1.47	8.4	1.96	16.5
1978	4.4	1.23	5.5	2.89	15.7	5.4	1.44	7.8	1.92	15.0
1977	4.2	1.36	5.7	2.61	14.9	5.3	1.43	7.6	1.87	14.2
1976	3.4	1.34	4.7	2.72	12.8	5.4	1.42	7.5	1.87	14.0
1975	2.9	1.27	3.8	2.90	11.0	4.6	1.35	6.2	1.87	11.6
1974	2.9	1.28	3.7	2.81	10.4	5.5	1.46	8.0	1.86	14.9
1973	2.9	.83	2.4	4.29	10.3	4.7	1.38	6.5	1.97	12.8
1972	2.4	1.13	2.7	3.19	8.6	4.4	1.25	5.5	2.02	11.1
1971	1.8	1.11	2.0	2.90	5.8	4.1	1.24	5.1	1.90	9.7

P-Preliminary

If the foregoing is valid, then understanding the difference between profit and profitability and the significance of that difference is critical to successful implementation of the DOD Acquisition Improvement Program. Analysis of defense contractor reactions to low contract profit will help clarify why this is so.

Study Table I, which compares the three measures of profitability, asset turnover, and the use of financial leverage in the aerospace industry against the same measures for all manufacturing firms over a 10-year period.[4] Note that profit margin (NI ÷ S) in the aerospace industry has been low relative to the average of all manufacturing firms in each year.

Profit margin, remember, is affected by the spread between price and cost. Do the technical risks inherent in modern weapon systems justify relatively low financial rewards? Do normal market forces related to defense sales cause relatively low profit margins, or is it a fear of public reaction to "excess" profit on defense business that leads to this result? Cannot the relatively low profit margins experienced by the aerospace industry be attributed in large measure to government attempts to cap defense contract profit?[5]

If company management believes that profit levels are too low relative to defense-product related risks, and if it is convinced that a meaningful increase in defense contract profit is not attainable, it has two alternatives with regard to market participation. First, it can get out of the defense contracting business entirely. Second, it can reduce the firm's exposure to the risks associated with defense business through diversification into the commercial sector. Small firms, which make up the third and fourth tier in the defense industrial base, have chosen the former.[6] Large firms, which cannot easily disengage from the first or second tier, opt for the latter or else strive for sole-source positions from which they can struggle in a monopsonistic market to achieve a more favorable balance between risk and reward.[7]

Each of these reactions on the part of industry increases the price of national defense to the extent that it results in unnecessary shrinkage of our defense industrial base and a loss of true competition in the system acquisition process.

There is yet another reaction with regard to low contract profit that increases the cost of national defense in general and weapons systems in particular. Profitability, in terms of return on investment, can be improved even if profit margin remains constant. The trick is to increase the amount of sales dollars generated for each dollar tied up in assets—to increase the asset turnover ratio. This can be accomplished through *added* investment only if sales dollars also increase. Avoiding added investment is a tempting course of action when profits are low and sales growth is uncertain due to customer buying habits and more apparent than real due to the effects of inflation. Failure to modernize facilities and equipment dedicated to defense work is a viable business strategy if the firm is simultaneously reducing its participation in the defense market. The result, unfortunately, is a decline in productivity and an increase in unit production cost in the defense sector.

Refer to the table above again. Note that asset turnover *and* return on investment in the aerospace industry are both below the averages for all manufacturing firms. Are the manufacturing processes for defense products so different that they mandate less efficiency in the use of assets to generate sales? Does the government's need for a warm industrial base lead to overcapacity and underutilization of existing assets? Considering the limited defense sales opportunities available, should it surprise us that prudent businessmen avoid overinvestment in cost-reducing facilities and equipment dedicated to defense business when the price of major weapon systems is established on a cost-plus-markup basis? Why take on the added risk of a modernized asset base for defense work when defense-related profits *and* profitability may fall as a result? The choice between profit and patriotism may be clear-cut when war is at hand; not so when defense posture is a political issue rather than an economic necessity.

Finally, take a look at the defense industry's use of borrowed funds to finance its investment in assets. In 1980 the

aerospace industry had approximately $3.06 in assets for each dollar of stockholder's equity. The average for all manufacturing firms, on the other hand, was quite a bit less. Keep in mind that the use of debt financing does not reduce the cost of assets, nor does it reduce the amount of time, money, and talent required to transform technology into hardware. It runs counter to conventional wisdom to combine low return on investment with high financial leverage unless return on investment is relatively risk free. Is this the case in the defense contracting business, or is it the government's potential involvement as lender of last resort that enables some companies in one sector of the American economy to achieve competitive returns on equity through financial techniques rather than operational performance? Would there be as great a need for the government to act as banker to the defense industrial base if return on investment in the defense sector was competitive to begin with? Would we be faced with a lack of productive capacity if profit margins on defense work were higher? Given the limited potential for defense business, should we not consider a realistic balance between risk and reward on a contract-by-contract basis as a valid solution to the problems we now face?

What Now?

I have oversimplified a complex problem in my discussion of the financial forces that impact business decisions. None of the issues raised is new. They have been debated again and again within and between government and industry. What is so troublesome is that the debate usually leads to a compounding of the problem rather than to its solution. Fear of excess profit has led to a maze of bureaucratic rules, regulations, and reports that strangle market forces and cause the disappearance of our subcontractor base. Efforts to maintain a "warm industrial base" contribute to overcapacity and undercapitalization at the prime-contractor level in the defense sector of our economy. Continuous bickering between the Congress and the Department of Defense over the cost of defense systems confuses the public and weakens its trust in our nation's leadership. The acquisition process would be much simpler and quicker if we could all agree that profit is a prerequisite for healthy competition and willing investment, and that too much profit is not likely over the long run if market forces and the natural inclination of prudent businessmen to balance risk and reward are allowed to operate.

Successful implementation of the DOD Acquisition Improvement Program requires that we all recognize that *defense has its price* and that *the price will be paid in one form or another*. It is time to consider paying that price up front where it will do the most good. The simplest, soundest, and most direct economic route is to increase contract profit. That alternative, however, will be impossible to implement so long as profit is considered a dirty word when it comes to the defense of our nation.

Cited References

1. On April 30, 1981, Deputy Secretary of Defense Frank Carlucci announced major changes both in the acquisition philosophy and the acquisition process as practiced by the new administration. The major theme of the changes is to achieve enhanced readiness, reduced acquisition costs, and shortened acquisition time.

2. Return on investment and profit margin were calculated using the industry median figures for return on equity, financial leverage, and asset turnover as published in "Profitability Goes Through a Ceiling," *Fortune*, May 4, 1982, pp. 116–117.

3. *Ibid.*

4. Standard & Poor's, Industry Surveys, May 28, 1981, p. A28. The aerospace industry was selected for anlaysis because it includes many of the major participants in the defense weapon system market.

5. The 10 or 12 percent markup on allowable cost typical in major systems acquisition contracts often translates into a much smaller return on sales after unallowable costs and income taxes are taken into account as shown below:

Comparison of Profit on Cost vs. Profit on Sales

	Markup on Allowable Cost			
	10%		12%	
Allowable cost	$100.00		$100.00	
Plus Profit/Fee	+10.00		+12.00	
Equals Sales Price	110.00		112.00	
Less Unallowable Costs (Typically 1–3% of Sales)	−2.20		−2.24	
Less Allowable Costs	−100.00		−100.00	
Equals Pre-Tax Profit	7.80		9.76	
Less Income Tax at 46%	3.60		4.49	
Equals Net Income	$4.20		$5.27	
Profit on Sales*	$4.20 / $110.00	=3.8%	$5.27 / $112.00	=4.7%

*Note that the profit margins shown are about half the current rate of inflation (Spring 1982). Consider the fact that high interest rates and the effects of inflation can result in real profits of zero or below on defense contracts if cash flow from the government to the contractor lags too far behind his cash outlays. Cash flow and inflation are topics beyond the scope of this article, but their effects on actual contract profit are awesome and tend to exacerbate the problems described herein.

6. In 1967, there were approximately 6,000 companies in the defense industrial base. Today there are only about 3,500. "The Ailing Defense Industrial Base: Unready for Crisis," 96th Congress, 2d Session. December 31, 1980, p. 5.

7. Government sales as a percent of total sales for the companies comprising the 1971 Standard and Poor's Aerospace Industry was 69 percent. By 1980 that proportion had dropped to 48 percent. Source: Aerospace Industries Association as reported in Standard and Poor's, Industry Surveys, November 25, 1976, page A12, and May 28, 1981, p. 28.

DSB Adds Five New Members

Secretary of Defense Casper W. Weinberger has announced the appointment of five new members to the Defense Science Board. They are as follows:

Elaine Bond, Senior Vice President, Corporate Systems, Chase Manhattan Bank.

Dr. Frederick P. Brooks, Jr., Professor of Computer Science and Chairman of Department, University of North Carolina.

Vincent N. Cook, President, Federal Systems Division, IBM Corporation.

Dr. Donald A. Hicks, Senior Vice President, Marketing & Technical, Northrop Corporation.

Admiral Bobby R. Inman, USN (Ret.), President and Chief Executive Officer, MCC Corporation, and former deputy director of the Central Intelligence Agency.

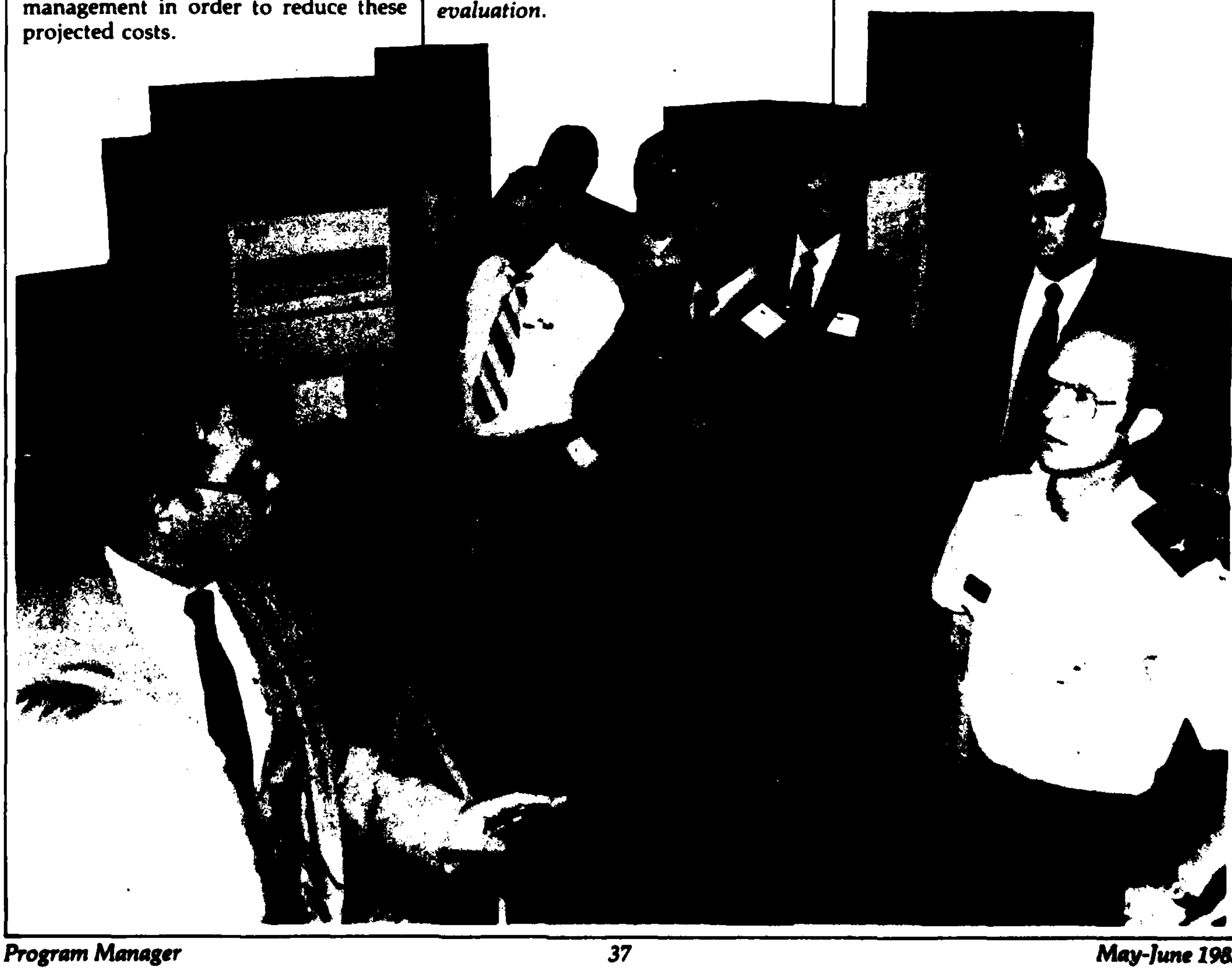
The Defense Science Board, chaired by Norman R. Augustine, President, Martin Marietta Denver Aerospace, is the senior advisory group in the Department of Defense. It is composed of members appointed from the public sector, who advise the Secretary of Defense, the Under Secretary of Defense for Research and Engineering, and the Chairman, Joint Chiefs of Staff, on technical and related matters of high importance to the Department of Defense.

Initiatives for Building Adaptability and Reliability into Software System Design

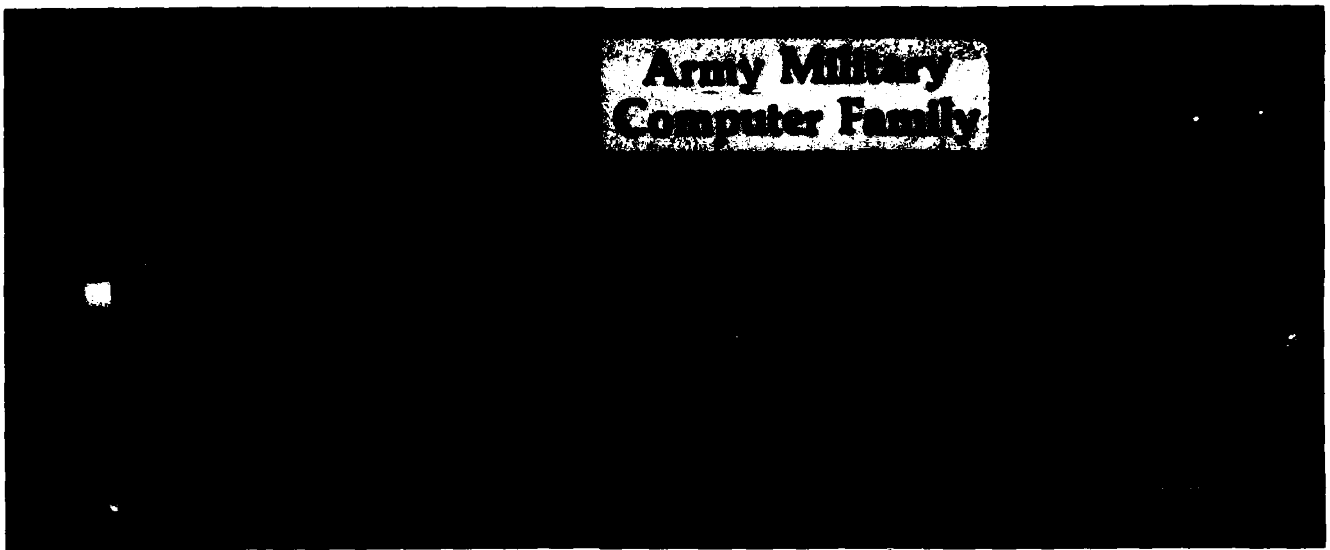
Colonel Kenneth E. Nidiffer, USAF

Estimates by independent sources indicate that DOD's investment in mission-critical computer software could increase from approximately $3.0 billion in 1980 to more than $30 billion in 1990. Most current and projected costs are associated with integrated logistics support. Therefore, new approaches and engineering design philosophies need to be developed and applied to software management in order to reduce these projected costs.

Traditional software maintenance largely consists of either tasks and procedures for restoring the operational capability of a system upon a software failure, or software redesigns intended to add new requirements. A logical solution to reducing software support costs would be to system engineer the software system design to more efficiently and effectively handle software maintenance problems.



Army personnel, including Major General Emmett Paige, Jr., USA, (center) Commander, Army Electronics Research and Development Command, attend a program review of the military computer family at RCA's Moorestown, N.J., facility. Raytheon and GE/TRW are in competition with RCA for the Army contract. Prototypes from all companies are now at Fort Monmouth, N.J., for test and evaluation.



Eight Initiatives for Software Support

As a result of the problems affecting software, DOD has undertaken several policy initiatives. The following eight are especially significant to software integrated logistics support:

—High-order language standardization;
—Instruction set architecture (ISA) standardization;
—Army and Navy Military Computer Families (MCF);
—Very-high-speed integrated circuits (VHSIC);
—Army post-deployment software support (PDSS) concepts;
—Embedded computer resources (ECR) acquisition standards;
—Education and training in software acquisition management;
—Software Technology for Adaptable Reliable Systems (STARS).

High-Order Language Standardization

The object of the high-order language standardization program is to develop a single high-order language—Ada*—for writing software for DOD mission-critical computer (real-time) applications. This effort is based on the idea that many of the post-deployment support costs for software increase with the number of languages, and that languages must be suited to their applications. Furthermore, with a common programming language, a software development and maintenance environment could be built, providing centralized support and common libraries that could be shared by several projects working in the same application area. For example, at least 200 general-purpose programming languages and dialects are used in DOD mission critical computer applications.

▲

Super Minicomputer (left)

Speed:	*3 MIPS*
Memory:	*2M bytes*
Cost:	*$75K*
Reliability:	*10K hrs. MTBF*
Volume:	*0.52. cu. ft.*
Power:	*100 watts*
Weight:	*40 lbs.*

Single Board Computer (center)

Speed:	*500 KIPS*
Memory:	*128 bytes*
Cost:	*$5K*
Reliability:	*100K hrs. MTBF*
Volume:	*0.02 cu. ft.*
Power:	*5 watts*
Weight:	*12 oz.*

Microcomputer (right)

Speed:	*500 KIPS*
Memory:	*1M bytes*
Cost:	*$25K*
Reliability:	*33K hrs. MTBF*
Volume:	*0.12 cu. ft.*
Power:	*20 watts*
Weight:	*10 lbs.*

■ *Colonel Nidiffer is a professor of system engineering and acquisition management in the Technical Management Department at DSMC.* ■

Instruction Set Architecture Standardization

The purpose of the instruction set architecture standardization initiative is to improve the control of the interface between software and the weapon system computer (target) environment. Standardization based on a selected computer architecture is a concept used by computer manufacturers to develop families of compatible computers. In this concept, the architecture remains constant, while it is physically implemented in different ways with different electrical and physical layouts. Architecture, in this sense, means the conceptual structure and functional behavior of a computer. That is, two comparable computer systems with the same architecture, but implemented differently in design, can carry out the same computer language program with identical results. Standardization based on a selected computer architecture can be physically implemented into new computers. This type of standardization is being considered because the length of the weapon system's life cycle often makes computers obsolete before, or shortly after, the system is deployed. In addition, a stable architecture provides a near-term answer to software transferability to a wide range of computer families.

*Ada is a registered trademark of the U.S. Department of Defense Ada Joint Program Office.

▲*The common computer programming language for the Department of Defense is "Ada" (a registered trademark). The language is named for Augusta Ada Byron, the Countess of Lovelace and the daughter of the English poet Lord Byron. She is generally considered the first programmer, having prepared the operating instructions (program) for Charles Babbage's analytic engine in the early 1800s.*

Military Computer Family

The military computer family program stems from a vital need for system survivability on the battlefield. At the hardware level, standard products will provide maximum interchangeability of hardware for survivability and maximum savings in logistics maintenance and training costs. The Army program calls for the delivery of two different computers—a super minicomputer (AN/UYK-41) and a microcomputer (AN/UYK-49). The Navy Tactical Embedded Computer Resource Program stems from the Navy's need to upgrade its two principal computers—the AN/UYK-7 and the AN/UYK-20. These computers are approaching obsolescence, and are experiencing speed and memory saturation in many applications. The AN/UYK-43 is the follow-on computer to the AN/UYK-7, the Navy's large computer; and the AN/UYK-44 is the replacement to the AN/UYK-20, the Navy's minicomputer.

Very-High-Speed Integrated Circuits

The VHSIC program is an initiative to obtain very-high-speed circuits with the high reliability needed for military missions. These circuits were not being developed in the commercial marketplace; therefore, DOD took the initiative to correct the shortfall. This effort is currently under competitive development.

Army Post-Deployment Software Support

The Army is implementing a Post Deployment Software Support (PDSS) program to support its systems. Software development, maintenance, and configuration management for systems deployed to tactical units on the battlefield are done centrally. (These systems are too complex to be programmed in the field.) The intent is to build support centers to maintain the software by mission area, e.g., missile, C³I.

ECR Acquisition Standards

The Joint Logistics Commmanders are sponsoring an initiative to improve the software acquisition standards. Currently, acquisition standards vary by service and, in general, are not current with established software acquisition management practices. A single set of draft standards is being reviewed by both government and industry.

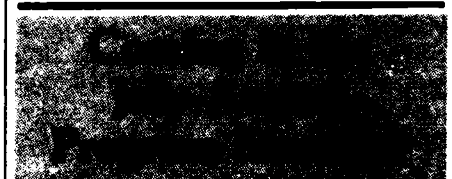
Education and Training

Education and training in software acquisition management is being given formal status with the formulation of the Personnel, Education, and Training (PET) Panel under the DOD Management Steering Committee for Embedded Computer Resources (MSC/ECR). A major output of the PET Panel has been the development of the Management of Software Acquisition Course now being offered by the Defense Systems Management College, both in residence and at regional centers across the United States.

Software Technology for Adaptable, Reliable Systems Program

The Department of Defense established the Software Technology for Adaptable, Reliable Systems program to address a broad set of problems associated with mission-critical software and the rapidly growing dependence of defense systems on computer technology. The goal of the STARS program is to improve software productivity while achieving greater systems reliability and adaptability. The improvement of software quality through a development and life-cycle support process that is faster, less expensive, and more predictable is an essential part of the program. The general strategy is to advance the technology base, to improve the personnel base, and to facilitate changes in current practices that will encourage widespread use of the advancing technology.

In summary, there are no pat answers to all the management questions posed in the quest for adaptable and reliable software-intensive weapon systems. But some relief from the high support costs of current and future software intensive weapon systems must be found, and that such relief will be gained more effectively by implementation of the management initiatives presented.



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Thomas J. Murrin Honored by NSIA, Cites Challenges to U.S. Industry

Former DSMC BOV Member Receives 30th James Forrestal Memorial Award

Thomas J. Murrin, President, Energy and Advanced Technology Group, Westinghouse Electric Corporation, is the 1982 recipient of the James Forrestal Memorial Award. He was a defense industry representative on the DSMC Board of Visitors from January 1981 through June 1982.

The National Security Industrial Association (NSIA) has presented the Forrestal Memorial Award annually since 1954 when the recipient was President Dwight D. Eisenhower. The award is bestowed on an American whose leadership has promoted significant understanding and cooperation between industry and government in the interest of national security. Forrestal, the first Secretary of Defense, believed that a continuous and close partnership between industry and government was essential.

Murrin accepted the award and spoke at a dinner held March 16 at the Sheraton Washington Hotel in Washington, D.C. This article is based on his remarks.

The United States is involved in two worldwide competitions. One is the military and political competition our nation faces with the Soviet Union. The other is the intense industrial and commercial competition we face in the international marketplace, particularly with the Japanese. Success in both of these competitions is critical if we are to guarantee the continuation of our standard of living and the survival of the freedoms that have made this country great.

Our opponents are attempting to parlay several of their advantages into victory, including more engineers and technical workers, greater investments for the future, and a consensus-based approach toward problem-solving and policy-formulation.

We in industry must think open-mindedly and creatively about how we can increase our nation's military and industrial strength.

In the technical manpower area Soviet statistics are worrisome. They apparently graduate more than 250,000 engineers per year, a 5-to-1 advantage over us. Japan graduates about twice the number of engineers we do, even though it only has half our population. Japanese engineers concentrate on industrial initiatives, and the Soviet engineers develop military might. Our engineers must compete in both arenas, simultaneously.

Regarding investments, the Soviets are outspending us in the military competition by about 2 to 1. The Japanese are substantially outspending us on "factories-of-the-future" comprising advanced flexible manufacturing systems, and on crucial technologies in the semiconductor, computer, and telecommunications fields.

We hear of Soviet government officials, military leaders, and key industrialists working together to develop and deploy new weapon systems in much less time than it takes us, albeit in an environment of fear and suspicion.

The Japanese have created a national industrial strategy and a set of institutional relationships to implement it. This includes a close relationship among industry, government, labor, and academe, and an organization, their Ministry of International Trade and Industry, to orchestrate the process. Studies in South Korea, Taiwan, Hong Kong, and Singapore indicate that it is now the Japanese model, not the American one, that is being emulated by newly industrialized countries.

Nevertheless, I am confident we can win both of these competitions, because we have the technology, the people, and other resources to meet all military and economic challenges. But, our response will probably be insufficient if things continue on their present course; operating the same way as in the past is no longer sufficient. We must choose different approaches.

I am not suggesting that we copy our competitors' systems. Rather, the challenge is to find a uniquely American response that calls upon our creativity and ingenuity to protect our standard of living and assure national security.

We need to choose goals that will unleash the creative American genius, that has been too long buried in bureaucracy and too long stifled by micromanagement. We need to choose trust over burdensome restrictions. We need to choose a rebirth of the American entrepreneurial spirit over a continuation of the frustration plaguing our nation.

We need to choose new approaches and new technologies that will allow us to protect our leadership where it still exists, and to recapture it where it has been lost.

We need to choose consensus leadership over adversarial relationships. We need to choose action over rhetoric. And, we need to take action so that our factories, our products, and our management are second to none. We are free to make all of these choices.

One key to our long-term competitive viability is a national strategy, supported by us all, aimed at quality and productivity improvement. Such an effort can restore our industrial base, create new jobs, and improve our balance of trade—while guaranteeing economic survival and national security.

We need to establish a cooperative relationship among industry, government, labor, and academe that, in the past, was achieved only in an emergency—such as war. When we work in a cooperative and complementary fashion, the most difficult challenges become manageable. If recognition of such problems is a precursor to their solutions, we seem to be making some progress. Many national leaders have recognized our quality and productivity problems. More voices from the boardrooms of corporate America are speaking out, and many industry executives are becoming deeply involved. We see interest in quality and productivity improvement on our college campuses. Our labor leaders are beginning to address the issue. The federal government has acknowledged the problem and has begun to ponder the initiatives to be undertaken.

What we seem to lack are effective mechanisms to bring the leaders of these elements of society together, on neutral ground, in pursuit of our common goals.

We in defense industry have the opportunity and the responsibility to lead the way in meeting the military and economic challenges threatening our nation. We must establish precedents and set trends that become the standards for productivity and quality improvement.

With our team talents, we can and must improve the quality and reliability—and reduce the cost and procurement time—of weapon systems. We can and must revitalize American industry. We in industry must think open-mindedly and creatively about how we can increase our nation's military and industrial strengths.

We have an education and training system poorly matched with the skills needed for modern jobs.

To do this, we must develop more "people power." Coupled with our shortage of engineers, we have an education and training system poorly matched with the skills needed for modern jobs. Many American workers are not as well-trained or motivated as the workers of our foreign competitors.

To correct this, we need to formulate an effective alliance with educational institutions to improve technical training and to satisfy the shortage of scientific and vocational skills. We in industry and government must retrain people throughout their careers to avoid technical obsolescence. Along with this commitment, we need to find ways to get more for our technology dollar in the face of increasing budget pressures. We need to protect our IR&D funds, and to dramatically expand our TECHMOD and MANTECH programs. Bold and innovative very-high-speed integrated circuit or VHSIC program-like initiatives should be undertaken in gallium arsenide semiconductor devices, in fiber optics, in smart robotics, and in advanced-generation computers.

We need to become more creative in exploiting new technologies, not only in the military sphere, but for commercial applications that will help us in industrial competition. For example, combining defense industry's genius in VHSIC, adaptive processing, and artificial intelligence can lead not only to "smart robots" for DOD applications, but also to the next generation of robots for commercial factories.

If we are to ensure that our technological leadership does not continue to erode, and to assure the highest value for our limited research and development dollars, we must cooperate in research ventures focused toward supplying the next generation of critical technologies. We should form nationwide "centers of excellence" in critical technologies. Such programs can synergistically aggregate, for the benefit of all, technology know-how that represents years of individual effort and millions of dollars in expense. Such cooperative technology programs could aid tremendously in expediting the improvement of our industrial base.

In this regard, TECHMOD programs should soon cover flexible manufacturing systems, advanced robots with "seeing-and-thinking" capabilities, and "just-in-time" production systems.

Perhaps the greatest challenge is to determine how we can focus the combined talents of traditional American competitors on cooperative ventures without destroying the creativity inherent in the free-enterprise system. We must discard outmoded policies and practices. We must replace bureaucratic restrictions with streamlined management systems. We must make more use of multi-year procurement, and other means of increased program stability. We must adopt a consensus-based policy to resolve issues on which there is broad agreement that solutions must be developed and implemented. Industry, government, labor, and academe must act in concert to integrate new initiatives.

A strong and powerful national defense can be built only on strong economic foundations. The next several years are critical in regaining the yardage we have lost. We can, and must, restore our position of military and economic leadership.

OBITUARY

John H. Richardson,
Hughes President, Former BOV Member

John H. Richardson, 60, President of Hughes Aircraft Company and a former member of DSMC's Board of Visitors, died in late March after a long illness.

During most of the 1970s, Mr. Richardson was a regular participant in DSMC's Distinguished Guest Lecturer Program. In 1978 he became one of the first to be named Honorary Professor at the College. He served as a defense industry representative on DSMC's Board of Visitors from July 1, 1978, through June 30, 1982. Mr. Richardson wrote articles for the *Defense Systems Management Review* and the *Program Managers Newsletter* and regularly referred potential authors to the College publications.

Mr. Richardson worked for Hughes, a leading defense contractor, since 1948, and had been president since 1978. His early positions with the company included Contract Supervisor; Manager of the Dayton office; Director, Military Sales; and Vice President and Assistant Aerospace Group Executive.

He was named Senior Vice President, Aerospace Group, in 1967 and Corporate Senior Vice President-Operations in 1969. He was appointed Senior Vice President and Assistant General Manager in 1976 and Executive Vice President in 1977.

After Mr. Richardson became President of Hughes, the company expanded to become the largest employer in Southern California and the largest manufacturing employer in the state, with approximately 60,000 employees.

In the 1970s and early 1980s, Mr. Richardson emerged as one of the aerospace industry's leading spokesmen on Defense Department procurement policies that would strengthen

NATO. He testified before congressional committees, military panels, and other boards on behalf of the Aerospace Industries Association.

He was a member of the Defense Science Board and served as Chairman of the Board of Advisers of the National Contract Management Association. He was a Director of the Ducommun, Inc., the Investment Company of America, the National Aeronautic Association, and the National Athletic Health Institute.

Mr. Richardson is a native of Auburn, N.Y. He attended Princeton University and completed executive programs at the University of California, Los Angeles, and the Massachusetts Institute of Technology.

He joined Hughes after serving as a B-29 pilot during World War II.

Mr. Richardson is survived by his wife, father, and a half brother.

(continued from page 5)

AFLC Commander Sees IR&D as a Key to Improved Military Readiness

the economic realities that, in effect, we in the military have created.

This means that the military must make the pursuit of improved reliability and supportability attractive to the defense contractor. We must place more emphasis on supportability and durability ourselves, and we must incentivize the contractor to do the same.

It seems to me that not only is the world changing, but the nature of warfare is changing, accelerated by an expanding base of communication, transportation, and military technology. In the modern combat environment, the only meaningful measure of a weapon system is force on force, the ability of that system to perform on short notice at the far corners of the globe.

We in the military are working hard to alter the course of past practices, and to reflect changes in our development contracts. As we design new weapon systems and consider modifications of present ones, both the military and defense industry must work to adjust the traditional mind-sets that have placed us in the dilemma I have described.

Change Traditional Support Structure

If we both alter our courses, we can move collectively toward a substantial change in traditional support structure—one characterized today by the unreliable manpower- and spares-intensive systems. Corporate IR&D, driven by clearly stated service requirements, can give us the weapon systems we need to deter potential enemies, and, failing that, the kind that will allow us to fight and win.

When we talk of national defense, we are talking about the ability to match our systems against the enemy systems, and to come out on top. Consequently, we are talking about our ability to support these weapon systems in the first place. That is what defense is all about, and what we in the defense community are all about.

INSIDE DSMC

DSMC Photographer Awarded 4-Year Navy Scholarship

Edward A. Baxter, Photographer's Mate Third Class, U.S. Navy, who has been the DSMC photographer since November 1981, has won an NROTC 4-year scholarship to the University of Washington, Seattle, beginning with the 1983 fall term. He plans to major in aeronautical engineering.

Baxter is one of 203 fleet men and women selected for the Naval Reserve Officer Training Corps program. The scholarships add up to about $40,000 each, depending on the college or university a student attends. The Navy pays for tuition, textbooks, instructional fees, and uniforms, and grants a $100-a-month subsistence allowance. The regular pay and allowances of fleet personnel stop when they join an NROTC unit. The Navy Recruiting Command has been urging Navy and Marine Corps enlisted personnel to apply for NROTC scholarships, the majority of which were formerly offered to the civilian community.

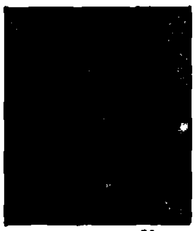
When PH3 Baxter leaves DSMC, probably in late August, he will be discharged from active duty and appointed a midshipman in the reserve; upon graduation from the University of Washington, he will be commissioned an ensign in the U.S. Navy.

At Trinity High School in Weaverville, Calif., from which he graduated in 1980, Baxter was class president for 4 years; yearbook editor in chief; recipient of the Administrator Leadership Award; president of the Photography Club; and active in sports programs, receiving a varsity letter in track and field. He enlisted in the Navy in May 1981 and was assigned to basic training at the Naval Training Center, San Diego. In July 1981, he was assigned to the Naval Photo School, Pensacola, Fla., where he was an honor student. Since then, he has been the DSMC photographer, covering a variety of official and unofficial assignments for the Graphic Arts Division. Baxter's work has appeared regularly in *Program Manager*, the DSMC annual catalog, and other DSMC brochures and publications.

Baxter is the son of Mr. and Mrs. Edward W. Baxter of Phoenix, Ore.

PEOPLE ON THE MOVE

Brown



Kerns

Calvin Brown is a professor of engineering management, Research Directorate, Department of Research and Information. He comes from the Joint Cruise Missile Project Office, Arlington, Va. Mr. Brown holds a B.S. degree in mechanical engineering from the University of Wyoming, Laramie, and an M.S. degree in aerospace engineering from the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

Ms. Radean M. Kerns is the protocol officer, Office of the Commandant. She comes from Fort Myer, Va., where she was director of the Military District of Washington Recreation Center. Ms. Kerns received a B.S. degree in recreation from Central Washington State College, Ellensburg.

Moser

Webster

Charles N. Moser has joined the staff as a professor of financial management, Business Management Department, School of Systems Acquisition Education. His last assignment was with the U.S. Air Force, Wright-Patterson Air Force Base, Ohio, where he was financial manager for the KC-10 program. Mr. Moser holds a B.S. degree in administration from Ohio State University, Columbus.

Dr. Anthony Webster is a professor of financial management, Business Management Department, School of Systems Acquisition Education. His last assignment was at the Armament and Materiel Readiness Command, Rock Island, Ill., as the economist, and inflation focal point. Dr. Webster holds a B.S. degree in agricultural economics from Florida A&M University, Tallahassee; an M.S. degree, also in agricultural economics, University of Arizona, Tucson; and a Ph.D. degree in economics, Columbia Pacific University, Mill Valley, Calif.

Other Staff Additions:

Seaman Ida Edwards, USN, to the Audiovisual Division, from the Naval Alcoholic Safety Action Program, Alexandria, Va.

Staff Losses:

Dr. Andrew P. Mosier, Professor of Acquisition/Program Management, Department of Research and Information, retired.

Commander Allen L. Cahill, USN, Business Management Department, School of Systems Acquisition Education, retired.

Teresa Tester, Administrative and Personnel Service Directorate, Department of Administration, to the U.S. Army Inspector General Agency Training Division, Fort Belvoir, Va.

Bruce Baird, Professor of Acquisition/Program Management, Department of Research and Information, to the Logistics Management Institute.

FY 84 Academic Program

The steady increase in the complexity of military systems and in the process used to acquire them calls for managers who are the "cream of the crop." Even if current efforts to streamline the acquisition process are successful, the challenge of meeting expanded requirements with reduced funding makes the job of the acquisition manager demanding and more complex. Thus, the need for trained and fully prepared acquisition managers is greater than ever.

The 2,000-plus students who attend courses in residence at DSMC each year represent only a small percentage of those who require specialized training offered at the College.

The DOD Acquisition Improvement Program (AIP), now into its third year, identified many actions to improve the manner in which we conduct our acquisition business. The College played and continues to play a vital role in getting the word out on the AIP initiatives. The initiatives have been incorporated into all the courses taught at DSMC. And, courses have been changed and new courses added to the curriculum to reflect the ever-changing needs of the program manager. A vigorous effort is made to relate every aspect of education at DSMC to an appropriate facet of activity in a project or program office. A total of six new courses are being offered in FY 84.

New course offerings are the Policy and Organization Management Package Course (POM-Pkg), Business Management Package Course (BUS-Pkg), Technical Management Package Course (TECH-Pkg), Joint Service Program Managers Workshop (JSPMW), Technical Managers Advanced Workshop (TMAW), and the Management of Acquisition Logistics Course (MALC).

DSMC Academic Program Continues to Evolve

These new 3-week package courses are designed to provide management students with an integrated and holistic understanding of the disciplines within a functional area. Attendance is required for all 3 weeks of a package course. All the package courses will be presented in 3 consecutive weeks. Descriptions of package courses follow.

Policy and Organization Management Package Course

The 3-week Policy and Organization Management Package Course provides an introduction to the concepts, scope, and application of program management practices within DOD. Attending the course will (1) equip the student to function in a program management office, or to interface effectively with the program management office through the development of an understanding of acquisition policies, tasks, problems, and issues confronting the program manager; (2) develop an understanding of the roles, activities, and integration of functions and relationships of government and industry organizations that participate in and affect the acquisition process; and (3) develop an understanding of the importance of interpersonal relations and communication skills in the development of an effective acquisition team. This course allows middle managers to develop sound management abilities and to experience the practices and problems of program management op-

INSIDE DSMC

Honorary Titles Reflect DSMC Appreciation

Colleges and universities regularly award honorary titles to individuals who support the institution. The Defense Systems Management College (DSMC) is no exception.

The College awards Honorary Professorships and Professors Emeritus status to individuals who have made significant contributions to its growth and academic standing.

A Professor Emeritus designation may be conferred on deserving ex-faculty members who continue to provide outstanding support for the College. To date, there are five Professors Emeritus.

Honorary Professorships are conferred upon individuals outside the College who have made substantial contributions through lectures or other professional activities that merit special recognition. Since this program started in the mid-1970s, 30 individuals have been awarded Honorary Professorships. (One of the early recipients of this designation was John Richardson whose obituary appears elsewhere in this issue of *Program Manager*.)

PMC Graduate Update

PMC 74-2

John A. Wyatt has left the Naval Electronic Systems Command where he served as Program Manager of the Navy's Standard Electronic Modules (SEM) Program, Head of the NAVELEX Components Engineering Branch, and U.S. Principal Member of NATO Study Group AC/301(SG/1)STG/6. He has taken a position as Staff Engineer in the Office of the Under Secretary of Defense (Research and Engineering) (OUSDRE) Defense Materiel Specifications and Standards Office (DMSSO) effective February 20, 1983.

PMC 82-2

Colonel Victor R. Shavers, USA, was promoted to his current rank on March 1, 1983. He is Test Manager, Command, Control, Communications and Intelligence (C3I), at the U.S. Army Operational Test and Evaluation Agency, Falls Church, Va. 22041.

PMC graduates: Send your input for PMC Graduate Update to Inside DSMC, Publications Directorate, Defense Systems Management College, Fort Belvoir, Va. 22060. Be sure to include your PMC class number.

Lists Six New Courses

erations. This course emphasizes the fundamentals of program management, defense acquisition policy, human behavior, and effective communications.

Business Management Package Course

The 3-week Business Management Package Course is a new offering designed to acquaint system acquisition personnel with business functions of the government program office and the contractor. It presents an overview of the systems management function oriented to business issues. Discussion of such government topics as basic funds management concepts, cost estimating, program budgets, types of contracts and incentive arrangements, preparation of requests for proposals, and source selection planning is included. Contractor topics covered include basic financial concepts, annual operating plans, and proposal preparation. Basic cost control functions, including the cost/schedule control systems criteria, from both the government and contractor's perspectives, will be discussed.

This course includes lectures and discussions associated with program/-program office business functions and responsibilities and is designed for student participation.

Package courses are part of the move toward a restructured DSMC curriculum.

Technical Management Package Course

The 3-week Technical Management Package Course provides an introduction to the concepts, scope, and application of technical management disciplines (system engineering, integrated logistic support, test and evaluation, and production) to the systems acquisition process. Attending the course will (1) enhance the ability of staff or functional managers to interface with program management office technical efforts through development of a better understanding of the technical management process; (2) develop an understanding of the activities and integration of technical disciplines necessary in the acquisition life cycle; and (3) develop an understanding of the roles of government and industry organizations in the technical management efforts.

This course allows junior-level managers to develop a sound understanding of the technical management process through emphasis on the technical disciplines of systems engineering, logistics support, test and evaluation and production.

Who May Attend

These package courses have been designed primarily for DOD personnel with less than 3 years of acquisition management or related functional/staff experience. The intended audience includes military personnel in the ranks of O-2 through O-4 and Department of Defense civilians in the grades of GS-9 through GS-13. Individuals holding equivalent grades in other federal agencies or defense industry are also encouraged to attend.

BOOK REVIEW

The One Minute Manager

Kenneth Blanchard, Ph.D., and Spencer Johnson, M.D.
New York: Morrow, 1982, 111 pages, $15.00

Great emphasis is being placed on increasing productivity. The controlling factor is productivity in management, and that is the point made very effectively in *The One Minute Manager*.

Blanchard and Johnson have written a concise text on the basic elements of managing for productivity. They have defined this manager: "Effective managers manage themselves and the people they work with so that both the organization and the people profit from their presence."

Blanchard and Johnson provide in a concentrated form the basic elements of the actions that the manager must take to be effective and to permit himself/herself and his/her co-workers to be efficient. These elements include: "One Minute Goals," signifying agreement between the manager and the worker as to what is to be done *and* the performance standard for measuring the work; "One Minute Praisings," which are prompt and positive comments on good behavior; and "One Minute Reprimands" that emphasize prompt feedback on wrong behavior—not the wrong person, but wrong behavior—followed by a positive statement on the worth of the individual.

In an understandable manner, management by objective, by exception, and by coaching are clearly explained in ways that the individual manager can adapt to his/her personality and style. The "One Minute Manager" concepts are presented simply, and yet each concept is capable of complex applications so that a manager may continuously apply the concepts in an ever-improving mode.

This small, delightful book can be a boon to managers with time control, personnel, and delegation problems.

Blanchard and Johnson conclude that "good management is a gift—share it."

Dr. Jay C. Billings